AMERICAN SOCIETY
FOR
TESTING MATERIALS

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS
OF THE
THIRTY-FOURTH ANNUAL MEETING

Held at Chicago, Ill.
June 22-26, 1931

VOLUME 31

PART I. COMMITTEE REPORTS
NEW AND REVISED TENTATIVE STANDARDS
TENTATIVE REVISIONS OF STANDARDS

PUBLISHED BY
AMERICAN SOCIETY FOR TESTING MATERIALS
1315 Spruce Street, Philadelphia, Pa.

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Printed in Philadelphia, U. S. A.
December, 1931

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Submitted or Revised, 1931

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American Society for Testing Materials

ORGANIZED IN 1898

INCORPORATED IN 1902

PROCEEDINGS, PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

SUMMARY OF THE PROCEEDINGS OF THE THIRTY-FOURTH ANNUAL MEETING

Chicago, Ill., June 22–26, 1931

The Thirty-fourth Annual Meeting of the American Society for Testing Materials was held at The Stevens, Chicago, Ill., June 22–26, 1931. The following is an analysis of the registered attendance at the meeting: Members in attendance or represented, 844; guests, 607; total, 1451; ladies, 48. The corresponding statistics for the Thirty-third Annual Meeting are: Members in attendance or represented, 954; guests, 138; total, 1092; ladies, 269.

There were also approximately 140 exhibitors and their representatives who were registered for the First Exhibit of Testing Apparatus described below, which number is not included in the registration for the meeting.

The First Exhibit of Testing Apparatus and Machines sponsored by the Society was held in the Exhibition Hall of The Stevens in conjunction with the Thirty-fourth Annual Meeting. Twenty-eight commercial exhibitors had their apparatus and machines on display in thirty-three booths. In addition there were fifteen booths in which certain research laboratories and institutions and A.S.T.M. committees displayed special testing apparatus and equipment not manufactured or distributed commercially. There were three Society committees and ten research institutions in this group. The technical and educational aspect of testing rather than the purely commercial side was emphasized and all who took part in the Exhibit cooperated to create an atmosphere which would be in keeping with the technical nature of the Society's activities.

FIRST SESSION—TUESDAY, JUNE 23, 10 A. M.

Reports of Administrative Committees; Nomenclature and Testing

President K. G. Mackenzie in the chair.

President Mackenzie in opening the Thirty-fourth Annual Meeting called attention to the fact that a Society is a voluntary organization of individuals banded together for the common purpose of securing results of mutual benefit which could not be secured without such organization, and that the annual meeting was a fitting culmination of a year's cooperative effort by the committees through which the work of the Society is carried on. He reviewed briefly the accomplishments of the Society during the past year that were of unusual interest and called attention to the many activities of the Society's committees as outlined in the annual reports. He directed attention to the several features of this annual meeting which were of outstanding importance, namely, the symposiums on effect of temperature on the properties of metals, on malleable iron castings, on weathering characteristics of masonry materials and on abrasion testing of rubber. He cited especially the cooperation with other national engineering societies that had made these symposiums possible and also the joint meeting with the Western Society of Engineers on the economic significance of specifications for materials.

The President also called attention to the First Exhibit of Testing Apparatus and Machines being held as an adjunct of the annual meeting, arranged not as a commercial undertaking but intended to afford information on new developments in testing apparatus.

The minutes of the Thirty-third Annual Meeting were approved as printed in the 1930 Proceedings.[1]

The President appointed a Committee of Tellers consisting of T. R. Lawson, chairman, J. M. Darke and J. H. Smith to canvass the vote on the election of officers, the report of the tellers to be received at the Annual Meeting Dinner on Wednesday evening.

The report of Committee E-6 on Papers and Publications was presented from manuscript by the chairman, C. L. Warwick. On motion, the report of the committee was adopted.

The report of Committee E-9 on Correlation of Research was presented by the chairman, H. F. Moore. On motion, the report of the committee was adopted.

The report of Committee E-10 on Standards was presented by the chairman, T. R. Lawson. On motion, the report of the committee was adopted.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 11 (1930).

The report of the Executive Committee was presented by the Secretary-Treasurer, C. L. Warwick. The report discussed membership activities, including the establishment of a sustaining class of membership, local activities including the organization of district committees, activities of the numerous standing committees, publications, finances, publicity and promotional activities, exhibit of testing apparatus and machines, and administrative matters concerning relations with other societies and international relations on various standardization projects. The following revision of the By-laws recommended by the Executive Committee was approved for reference to letter ballot of the Society for adoption:

Article I, Members and Their Election.—Amend Sections 1 and 2 by providing for a class of Sustaining Members.

Article VI, Procedure Governing the Adoption of Standards.—Amend Section 2 to provide that questions affecting the proposed use in a standard or tentative standard of any device or process forming the subject matter of an existing copyright or trade mark be also submitted to the Executive Committee for review prior to submission to the Society as is the case with material covered by patent.

Article VII, Dues.—Amend Section 1 to provide for annual dues of $100 for Sustaining Members.

On motion, the report of the Executive Committee was adopted.

The report of Committee E-1 on Methods of Testing was presented by the chairman, W. H. Fulweiler. In presenting the report Mr. Fulweiler called on H. F. Moore to present the report of the Technical Committee on Mechanical Testing, on E. C. Bingham to present the report of the Technical Committee on Plasticity, Consistency, Etc., and on W. A. Shewhart to describe the work of the Technical Committee on Presentation of Data. On motion, the report of the committee was adopted, subject to a favorable letter ballot of Committee E-1.[1]

The report of Committee E-8 on Nomenclature and Definitions, Cloyd M. Chapman, chairman, was presented by the secretary, R. E. Hess. The approval by Committee E-8 for adoption as standard of the definitions for the terms "spalling" and "pyrometric cone equivalent" was reported. On motion, the report of the committee was adopted, subject to a favorable letter ballot of Committee E-8.[2]

A paper entitled "High-Temperature Characteristics of Metals Revealed by Bending" by Howard Scott was presented from manuscript by the author.

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[1] The report was submitted to letter ballot of the committee, which consists of 54 members; 33 members returned their ballots, all of whom have voted affirmatively.

[2] The report was submitted to letter ballot of the committee, which consists of 48 members; 29 members returned their ballots, all of whom have voted affirmatively.

At President Mackenzie's invitation, Thomas Spooner presided during the remainder of the session.

A paper entitled "Damping Capacity of Materials" by G. S. von Heydekampf was presented by the author and discussed.

A paper entitled "Methods for Determining the Physical Properties of Certain Rubber Compounds at Low Stresses" by R. L. Templin and R. G. Sturm was presented by Mr. Templin.

The meeting then adjourned till 2 p. m.

SECOND SESSION—TUESDAY, JUNE 23, 2 P. M.

On Paving and Waterproofing Materials; Coal and Timber

(Held Simultaneously with Third Session)

Mr. C. S. Reeve in the chair.

The report of Committee D-7 on Timber was presented by the chairman, Hermann von Schrenk. The report as preprinted recommended a revision for immediate adoption in the Standard Method of Test for the Distillation of Creosote Oil (D 246 – 30). As a result of further consideration of this revision, the committee decided to withdraw the proposed revision. In presenting the report Mr. von Schrenk called on S. R. Church to present the report of Subcommittee VI on Timber Preservatives. On motion, the report of the committee was adopted.

The report of Committee C-5 on Fire Tests of Materials and Construction, in the absence of the chairman, R. P. Miller, was presented by the secretary, Fitzhugh Taylor. On motion, the report of the committee was adopted.

The report of Committee D-4 on Road and Paving Materials was presented by the chairman, P. J. Freeman. The proposed revisions of the definitions of the terms "bitumens," "asphalts," "flux," "tars" and "pitches" appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 – 18) were accepted for publication as tentative. The addition of a note of caution regarding the high-distillation thermometer in the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 30) was recommended by the committee as an editorial change. On motion, the report of the committee was adopted.

A paper entitled "Modern Paving Emulsions, Types, Characteristics and Test Methods" by C. L. McKesson was presented by the author and discussed.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by the chairman, S. T. Wagner. The proposed revision of the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc or Mineral Granules, Likewise Asphalt Shingles Surfaced with Mineral Granules (D 228 – 30 T) was accepted, the methods as revised being continued as tentative. On motion, the report of the committee was adopted.

The report of Committee D-5 on Coal and Coke was presented by the chairman, A. C. Fieldner. The advancement to standard of the Tentative Method of Test for Size of Anthracite (D 310 – 29 T), as revised, was approved for reference to letter ballot of the Society for adoption. In presenting the report, the chairman recommended the addition of a statement concerning the activities of Subcommittee VIII on Foundry Coke Specifications including a paper entitled "Stability Tests on Semet-Solvay Coke for Standard Sample" by R. M. Fowler to be appended to the report. On motion, the report of the committee was adopted.

The report of Sectional Committee on Classification of Coals was presented by the chairman, A. C. Fieldner. On motion, the report of the committee was accepted for publication.

The meeting then adjourned till 8 p. m.

THIRD SESSION—TUESDAY, JUNE 23, 2 P. M.

On Effect of Temperature on the Properties of Metals

(Joint Session with American Society of Mechanical Engineers)

(Held Simultaneously with Second Session)

President K. G. Mackenzie in the chair.

The Report of Joint Research Committee of A.S.M.E. and A.S.T.M. on Effect of Temperature on the Properties of Metals was presented by the chairman, H. J. French. In presenting the report Mr. French called upon the various authors to present their reports and papers appended to the report, as follows:

"Progress Report on Fatigue Tests of Low-Carbon Steel at Elevated Temperatures," by H. F. Moore and N. J. Alleman—presented by Mr. Alleman.

"Apparatus for Low-Temperature Endurance Testing," by H. W. Russell and W. A. Welcker, Jr.—presented by Mr. Russell.

"New Creep Testing Apparatus at the Massachusetts Institute of Technology," by F. H. Norton and J. B. Romer—presented from manuscript by Mr. Romer.

On motion, the report of the committee was accepted for publication.

The President extended a cordial welcome to the members of the American Society of Mechanical Engineers at this joint session of the A.S.M.E. and A.S.T.M. on the Effect of Temperature on the Properties of Metals. He then introduced W. L. Abbott, Past-President of the A.S.M.E., who opened the Symposium on Effect of Temperature on the Properties of Metals sponsored by the A.S.M.E.-A.S.T.M. Joint Research Committee.[1] In opening the symposium, Mr. Abbott stated that in the rapidly expanding field of the application of metals at high and low temperatures it becomes useful at intervals to take stock of present knowledge and perhaps also to appraise recent accomplishments even though much progress is made each year. This symposium, arranged to coordinate the interchange of information or ideas relating to the effect of temperature on the properties of metals, also provided a means to discuss the engineers' needs for materials to withstand high temperatures and stresses and just how well available materials meet these requirements.

President Mackenzie then introduced A. D. Bailey and H. W. Gillett, chairman and secretary, respectively, of the first part of the Symposium. Mr. Bailey announced a novel feature in the holding of the Symposium, since more data had been accumulated than could be presented individually by the authors of the 28 papers at the two sessions, of which this was the first. Instead of having each individual paper presented by the respective author, the papers were divided into two groups, relating to the two major phases of the subject, the first of which on "Engineering Trends and Requirements for Metals at High and Low Temperatures," constituting 11 papers, was abstracted by L. W. Spring, a member of the Joint Committee and an investigator in this field.

The substance of this group of papers which discussed the subject from the engineers' viewpoint was then ably presented in abstract form by Mr. Spring, following which the papers, which are as follows, were discussed individually and in groups:

"Trends in Engineering Requirements for Metals for the Power Plant Industry—Steam Boiler and Superheater Division" by H. J. Kerr.

"Steam Turbine Materials for High Temperatures" by R. C. Allen.

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[1] The papers, complete with discussion, entering into this Symposium have been assembled in a separate volume entitled "Effect of Temperature on the Properties of Metals," published jointly by the two Societies.

"Metallurgical Requirements for High-Temperature Steam Piping" by F. W. Martin.

"Needs of the Oil Industry for Metals at High Temperatures" by E. S. Dixon.

"Corrosion and Other Problems in the Use of Metals at High Temperatures in the Chemical Industries" by F. H. Rhodes.

"Engineering Requirements and Trends for Metals in the Ferrous Metal Industries" by J. C. Woodson.

"Engineering Requirements and Trends for Metals in the Non-Ferrous Roasting, Smelting and Refining Industry" by R. E. Brown.

"Engineering Requirements in the Automotive Industry for Metals Operating at High Temperatures" by A. L. Boegehold and J. B. Johnson.

"Use of Metals at Elevated Temperatures in the Ceramic Industry" by C. E. Williams.

"The Trend of Progress in Great Britain on the Engineering Use of Metals at Elevated Temperatures" by R. W. Bailey, J. H. S. Dickenson, N. P. Inglis and J. L. Pearson.

"The Mechanical Properties of Metals at Elevated Temperatures" by Pierre Chevenard.

The meeting then adjourned till 8 p. m., the Symposium being continued in the Fourth Session.

FOURTH SESSION—TUESDAY, JUNE 23, 8 P. M.

Symposium on Effect of Temperature on the Properties of Metals

(Joint Session with American Society of Mechanical Engineers)

(*Held Simultaneously with Fifth Session; Continued from Third Session*)

President K. G. Mackenzie in the chair.

The Symposium on Effect of Temperature on the Properties of Metals, which had been opened in the Third Session, was continued in this session with a group of 17 papers on the second major phase of the subject, namely, "Properties of Available Metals for High- and Low-Temperature Service."

President Mackenzie introduced F. M. Becket and H. W. Gillett, chairman and secretary, respectively, of the second part of the Symposium.

Chairman Becket announced that the same procedure would be followed in this session as in the preceding one, and that the papers would be abstracted by H. J. French, chairman of the Joint Research Committee and an investigator in this field.

The substance of this group of papers which discussed the subject from the viewpoint of the metallurgist, to the end that the ultimate consumer may add to his accomplishments, was then ably presented in abstract form by Mr. French and following which the papers which are as follows were discussed individually and in groups:

"Zinc Alloys for High and Low-Temperature Service" by H. A. Anderson.

"The Mechanical Properties of Aluminum and Magnesium Alloys at Elevated Temperatures" by R. L. Templin and D. A. Paul.

"Properties of Bearing Metals at Normal and Elevated Temperatures" by E. R. Darby.

"Properties of Copper and Some of Its Important Industrial Alloys at Elevated Temperatures" by W. B. Price. With discussion by W. H. Bassett.

"High-Temperature Creep Properties of Wrought Carbon and Low-Alloy Steels" by A. P. Spooner and F. B. Foley.

"The Performances of Cast-Carbon and Low-Alloy Steels in High- and Low-Temperature Service" by R. A. Bull.

"Effect of Elevated Temperatures on Certain Mechanical Properties of Gray Cast Iron and Malleable Iron" by J. W. Bolton and H. Bornstein.

"The Wrought Austenitic Alloys" by R. H. Aborn and E. C. Bain.

"The Effect of Temperature on Some Properties of Iron-Chromium-Nickel Alloys" by N. B. Pilling and Robert Worthington.

"Nickel and Nickel Alloys Other than the Nickel-Chromium-Iron Group" by C. A. Crawford and Robert Worthington.

"High-Chromium Steels for Extreme Service Conditions" by C. E. MacQuigg.

"Properties of the Rare Metals for High-Temperature Service" by W. H. Swanger.

"Effect of Temperature on the Properties of Nitrided Alloys" by O. E. Harder.

"Effect of Low Temperatures on Metals and Alloys" by H. W. Russell.

"Thermal Expansion of Metals" by N. L. Mochel.

"Note on Applications of Data on the Thermal Conductivity of Metals" by M. S. Van Dusen.

"Supplementary Bibliography on Effect of Temperature on the Properties of Metals" by L. F. McCombs.

The meeting then adjourned till the following morning.

FIFTH SESSION—TUESDAY, JUNE 23, 8 P. M.

On Textiles, Rubber Products, Symposium on Abrasion Testing of Rubber

(Held Simultaneously with Fourth Session)

Mr. S. T. Wagner in the chair.

The report of Committee D-13 on Textile Materials, in the absence of the chairman, H. J. Ball, was presented by the first vice-chairman, K. B. Cook. The proposed Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating, Specifications for Enameling Duck for the Tire Industry, Specifications for 0.007-in. Cotton Tape and Method of Determining Relative Humidity were accepted for publication as tentative.

The proposed revision of the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 – 27) in the form of new tentative specifications was accepted for publication as tentative.

It was recalled that the revision proposed in 1930 of the Standard Specifications for Textile Testing Machines (D 76 – 27) which involved a patented device was accepted last year for publication as tentative subject to the approval of the Executive Committee of the Society after reviewing the situation in respect to patent features. The Executive Committee has recently granted permission to Committee D-13 to include reference to certain patented devices in the specifications upon satisfactory assurance of the owner of the patent that the patent will not result in an exorbitant price of these devices to the consuming public. This proposed revision of the specifications, which reads as follows, will accordingly be published as tentative:

Section 5 (a) Fabric Jaws.—Add the following new paragraph to this section:

> In the case of vertical or upright testing machines, where the upper jaws are not held in positive alignment, it is recommended that the lower jaw of the testing machine be provided with two tapered pins one on each side about ½ in. in diameter which project upward and are adjustable for different spacing between the top and bottom jaws. The upper ends of these pins shall fit into the tapered holes in the upper jaw when placing the specimen but disengaging when the jaws separate. In this way they regulate the distance between the jaws and hold them in positive alignment while the test specimen is being inserted.

The proposed revisions of the Tentative Specifications for Chafer Tire Fabrics (D 316 – 30 T), for Tolerances and Test Methods for Rayon (D 258 – 27 T) and Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods

(D 276–30 T) were accepted, the specifications and methods as revised being continued as tentative. On motion, the report of the committee was adopted.

The report of Committee D-11 on Rubber Products, in the absence of the chairman, W. B. Wiegand, was presented by the secretary, Arthur W. Carpenter. The proposed Tentative Specifications for Rubber Pump Valves were accepted for publication as tentative to supersede the present Standard Specifications for Rubber Pump Valves (D 151 – 23), the withdrawal of which specifications was accordingly approved.

The proposed revision of the Standard Methods of Testing Rubber Products (D 15 – 24) was accepted for publication as tentative.

In the report as preprinted the committee also recommended revisions in the Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 – 28 T). In presenting these revisions the committee also recommended additional changes in the revisions as preprinted and recommended that the specifications as thus revised be continued as tentative. These changes have been incorporated in the revisions recommended originally and are given in detail in the Appendix to the Report of Committee D-11 on Rubber Products.[1] The revisions in the original recommendations and changes in the specifications were accepted, the specifications as revised being continued as tentative subject to a favorable letter ballot of Committee D-11.[2]

The proposed revisions of the Tentative Specifications for Steam Hose (D 54 – 24 T) and Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 29 T) were accepted, the specifications and methods as revised being continued as tentative.

The committee withdrew its recommendation for advancement to standard of the Tentative Specifications for Rubber Insulating Tape (D 119 – 28 T) which appeared in the report as preprinted. On motion, the report of the committee was adopted.

Mr. Wagner then invited H. A. Depew to preside over the Symposium on Abrasion Testing of Rubber.

Mr. Depew in introducing the Symposium stated that ten years ago Committee D-11 on Rubber Products recognized that the work it was doing had gone as far as it could without the development of new performance tests that would evaluate rubber better than the methods that were in use up to that time. It was decided that this could be achieved best by devoting more time to the development of performance tests and in standardizing these tests. Accordingly a Subcommittee on Performance Tests was appointed in 1923, which was later divided into three subcommittees, namely, on Aging, on Flexing and on Abrasion.

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[1] See p. 550.

[2] The subsequent letter ballot on this recommendation resulted as follows: 26 affirmative, 1 negative, with 7 members not voting.

He stated that the Abrasion Testing Committee carried out a number of programs in correlation with laboratory tests and it was believed that a great deal of information had been collected on abrasion testing of rubber and that one of the important reasons for arranging for this symposium had been to offer an occasion where this information could be made available. He accordingly made an appeal for discussion to cover not only the papers presented but also other subjects of interest in connection with abrasion testing, including such subjects as correlation of service tests with laboratory tests, unusual service conditions and results, design of an ideal abrasion machine, and cutting tests and their value in determining abrasion resistance.

The papers comprising the symposium were then presented, as follows:

"Study of a Test for Tear Resistance of Vulcanized Rubber Compounds" by Arthur W. Carpenter and Z. E. Sargisson—presented by Mr. Carpenter;

"Abrasion Tests of Vulcanized Rubber Compounds Using an Angle Abrasion Machine" by J. L. Tronson and Arthur W. Carpenter—presented by Mr. Tronson;

"The Measurement of the Work Done in Punching a Rubber Cylinder from a Test Sheet" by H. A. Depew, S. I. Hammond and E. G. Snyder—presented by Mr. Depew;

"Abrasion Testing of Rubber with Bureau of Standards Type Machine" by W. E. Glancy—in the absence of the author presented by Arthur W. Carpenter;

"Comparative Tests of Four Abrasion Machines" by C. A. Klaman—in the absence of the author presented by H. A. Depew.

The presentation of these papers was followed by discussion.

The meeting then adjourned till the following morning.

SIXTH SESSION—WEDNESDAY, JUNE 24, 9.30 A. M.

On Steel, Wrought Iron, Magnetics

(Held Simultaneously with Seventh Session)

Mr. G. A. Reinhardt in the chair.

The report of Committee A-2 on Wrought Iron, in the absence of the chairman, H. W. Faus, was presented by the secretary, G. H.

Woodroffe. The revisions proposed for immediate adoption in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 30) were unanimously approved for reference to letter ballot of the Society for adoption, this recommendation requiring a nine-tenths vote. The proposed revisions of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30) and of the definition for the term "double-refined iron," appearing in the Standard Definitions of Terms Relating to Wrought-Iron Specifications (A 81 – 30), were accepted for publication as tentative. On motion, the report of the committee was adopted.

The report of the Sectional Committee on Standardization of Dimensions and Material of Wrought-Iron and Wrought-Steel Pipe and Tubing was presented by the chairman, H. H. Morgan. On motion, the report of the committee was accepted for publication.

The report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys was presented by the chairman, Jerome Strauss. On motion, the report of the committee was adopted subject to approval by letter ballot of the committee.[1]

The report of Committee A-1 on Steel was presented by the chairman, J. B. Young. The proposed Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives, and Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding were accepted for publication as tentative.

The revision proposed for immediate adoption in the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27) was unanimously approved for reference to letter ballot of the Society, this recommendation requiring a nine-tenths vote. The advancement to standard of the tentative revision of the Standard Specifications A 96 – 27, proposed last year, was also approved for reference to letter ballot of the Society for adoption.

The proposed revisions of the Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 27), for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27), for Steel Plates of Structural Quality for Forge Welding (A 78 – 30) and for Structural Silicon Steel (A 94 – 29) were accepted for publication as tentative.

The committee also recommended a revision of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30) for publication as tentative. After discussion the revision was on motion accepted for publication as tentative with the phrase "the design" changed to read "their design" in the second paragraph of the revised Section 11 (*a*) on Test Specimens, thus making this paragraph read as follows:

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[1] The report was submitted to letter ballot of the committee which consists of 47 members; 32 members returned their ballots all of whom have voted affirmatively.

> In case it is necessary to determine the tensile or bending properties of the bars without regard to their design, the specimens shall be machined to a uniform cross-section for a length of at least 9 in.

In addition to the recommendations concerning standards and tentative standards appearing in the report as preprinted, the committee recommended the following revision of the Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14) for publication as tentative:

Section 7 (*a*).—Change from its present form: namely,

> 7. (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

> 7. (*a*) Tension and bend test specimens for plain and deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars as rolled the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.
>
> In case it is necessary to determine the tensile or bending properties of the bars without regard to their design, the specimen shall be machined to a uniform cross-section for a length of at least 9 in.
>
> NOTE.—By this method the area in square inches may be obtained by dividing the weight in pounds per inch of specimen length by 0.2833 (weight of 1 cu. in. of steel); or by dividing the weight in pounds per foot of specimen length by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 9.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> 9. The weight of any lot of bars shall not vary more than 5 per cent [from] *over or under* the theoretical *or specified* weight of that lot. *The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars 3.8 in. and less.*

These revisions were by unanimous action accepted for publication as tentative subject to approval by letter ballot of Committee A-1.[1]

The committee withdrew the proposed tentative revision, recommended in the report as preprinted, of the process clauses of the

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[1] The letter ballot on this recommendation resulted in 69 affirmative, and 2 negative votes with 36 members not voting.

Standard Specifications for Low-Carbon-Steel Splice Bars (A 3 – 24), for Structural Steel for Buildings (A 9 – 29), for Steel Track Spikes (A 65 – 24), for Steel Screw Spikes (A 66 – 21), for Steel Tie Plates (A 67 – 30), for Low-Carbon-Steel Track Bolts (A 76 – 27), for Commercial Quality Hot-Rolled Bar Steels (A 107 – 30) and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 30). The Committee also withdrew the proposed revision, recommended in the report as preprinted, of the process clause in the Tentative Specifications for Soft Steel Track Spikes (A 65 – 26 T).

The proposed revision of the Tentative Specifications for Carbon-Steel Forgings for Locomotives (A 20 – 29 T) and for Heat-Treated Carbon-Steel Helical Springs (A 125 – 29 T) was accepted, the specifications as revised being continued as tentative. On motion, the report of the committee was adopted.

A paper entitled "The Measurement of Large Brinell Impressions in Steel Rails" by H. H. Morgan and J. R. Mooney was presented by Mr. Morgan and discussed.

A paper entitled "Some Physical Properties of Hardened Tool Steel" by J. V. Emmons was presented by the author and discussed.

The report of the Research Committee on Yield Point of Structural Steel was presented by the chairman, M. O. Withey. On motion, the report of the committee was accepted for publication.

The report of Committee A-6 on Magnetic Properties was presented by the chairman, Thomas Spooner. The proposed revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28) was accepted for publication as tentative. The proposed revision consisting of the omission of the name "oersted" for the unit of reluctance and substituting "oersted" for "rowland" as the name of the unit of magnetic force in the Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 30 T) was accepted, the definitions as revised being continued as tentative. On motion, the report of the committee was adopted.

The report of Committee A-8 on Magnetic Analysis was presented by the chairman, R. L. Sanford. On motion, the report of the committee was adopted.

A paper entitled "Thermomagnetic Analysis and the A_0 Transformation in 0.75-per-cent Carbon Steel" by R. L. Sanford and G. A. Ellinger was presented by Mr. Sanford and discussed.

A paper entitled "Relation Between Magnetic Properties, Impact Strength and Hardness" by Haakon Styri was presented by the author and discussed.

A paper entitled "The Unbalanced Alternating Current Bridge for Magnetic Analysis: II" by W. B. Kouwenhoven and J. H. Lampe, in the absence of the authors was presented by A. V. deForest.

The meeting then adjourned till 4 p. m.

SEVENTH SESSION—WEDNESDAY, JUNE 24, 9.30 A. M.

On Paints, Petroleum Products and Electrical Insulating Materials

(Held Simultaneously with Sixth Session)

Mr. H. E. Smith in the chair.

A brief report of progress of Committee D-17 on Naval Stores was, in the absence of the chairman, F. P. Veitch, presented by the Chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials in the absence of the chairman, Allen Rogers, was presented by the secretary, P. H. Cathcart.

In presenting the proposed Tentative Specifications for Beta Ethoxy Ehtanol (Synthetic) and for Beta Butoxy Ethanol (Synthetic) the secretary stated that materials covered by these specifications involved patents. The proposed specifications were accordingly accepted for publication as tentative subject to approval by the Executive Committee of the Society after reviewing the situation in respect to patent features.[1]

The proposed Tentative Specifications for Acetone, and the Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels were accepted for publication as tentative. The committee withdrew its recommendation for publication as tentative of the Specifications for Non-Corrosive 90-per-cent Benzene (Benzol), for Industrial Pure Toluene (Toluol), for Non-Corrosive Industrial Pure Toluene (Toluol), for Industrial Xylene (Solvent Naphtha), and for Non-Corrosive Industrial Xylene (Xylol) which appeared in the report as preprinted.

The committee recommended for publication as tentative the Method of Test for Tinting Strength of White Pigments. After discussion the recommendation was on motion approved and the method accepted for publication as tentative.

Revisions proposed for immediate adoption in the Standard Specifications for Red Lead (D 83 – 24) and for Basic Carbonate White Lead (D 81 – 24) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote.

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[1] The Executive Committee has not yet approved these specifications pending submission of certain information respecting the patent features of the specifications, and accordingly they have not been published as tentative.

The proposed revisions of the Tentative Specifications and Tests for Soluble Nitrocellulose (D 301 – 30 T) and the Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 – 30 T) were accepted, the specifications and methods as revised being continued as tentative.

The Tentative Specifications for the Toxic Ingredients in Anti-Fouling Paints (D 277 – 28 T), as revised, for Aluminum Powder for Paints (Aluminum Bronze Powder) (D 266 – 28 T), for Gold Bronze Powder (D 267 – 28 T), and Method of Test for Oil Absorption of Pigments (D 281 – 28 T), as revised, Test for Alkalinity or Acidity of Pigments (D 278 – 28 T), Test for Bleeding of Pigments (D 279 – 29 T), Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 – 28 T), Routine Determination of Acetone Extract in Dry Lampblack and Dry Bone Black (D 305 – 29 T), and Test for Determination of Polishing Lubricant in Aluminum Powder for Paints (Aluminum Bronze Powder) (D 306 – 29 T) were approved for reference to letter ballot of the Society for adoption as standards. On motion, the report of the committee was adopted.

A paper entitled "The Photo-electric Cryptometer" by A. H. Pfund was presented by the author and discussed.

A paper entitled "The Hiding Power of White Pigments" by G. S. Haslam and D. L. Gamble in the absence of the authors was presented by G. F. A. Stutz and discussed.

The report of Committee D-15 on Thermometers in the absence of the chairman, W. H. Fulweiler, was presented by the secretary, C. S. Reeve. The recommendation of the committee that a note of caution be added to the specifications for the high-distillation thermometer in those standards in which it appears was approved. On motion, the report of the committee was adopted.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the chairman, F. A. Hull. The proposed revisions of the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30) and Test for Distillation of Natural Gas Gasoline (D 216 – 30) were accepted for publication as tentative. The proposed revisions of the Standard Methods of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 30) and Test for Cloud and Pour Points of Petroleum Products (D 97 – 30) were approved as editorial changes.

The proposed revision of the Tentative Method of Test for

Determination of Vapor Pressure of Natural Gasoline (Reid Method) (D 323 – 30 T) and the tentative definition of the term "fuel oil" appearing in the Tentative Definitions of Terms Relating to Petroleum (D 288 – 28 T) were accepted, the method and definition as revised being continued as tentative. On motion, the report of the committee was adopted.

The report of Committee D-9 on Electrical Insulating Materials was presented by the chairman, H. L. Curtis.

The advancement to standard of the tentative revision of the Standard Methods of Testing Electrical Insulating Oils (D 117 – 27) was approved for reference to letter ballot of the Society for adoption.

The proposed revisions of the Tentative Methods of Testing Insulating Varnishes (D 115 – 30 T), of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 30 T), of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 – 27 T), of Testing Laminated Sheet Insulating Materials (D 229 – 30 T) and Test for Comparing the Thermal Conductivities of Solid Electrical Insulating Materials (D 325 – 30 T) were accepted, the methods as revised being continued as tentative.

The committee recommended the inclusion of two additional paragraphs in the report with reference to conditioning of test specimens for mechanical tests and temperature range during water absorption tests. On motion, the report of the committee was adopted.

The meeting then adjourned till 4 p. m.

EIGHTH SESSION—WEDNESDAY, JUNE 24, 4 P. M.

Edgar Marburg Lecture

President K. G. Mackenzie in the chair.

The President, in opening the session, summarized briefly the purpose and double significance of the Edgar Marburg Lecture, instituted in 1926 for the purpose of commemorating annually the name of the first Secretary-Treasurer of the Society, one who placed the work of the Society on a firm foundation and through whose supervision and foresight, through the developments of research activities and technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials; and also to bring to the Society men of especial distinction in various branches of the engineering profession to the end that the members might receive inspiration through the lecture and learn of the latest developments in the sciences of engineering materials in which the Society is interested.

The President then introduced the sixth Edgar Marburg Lecturer, Dr. A. Nadai, a graduate of the Technical University of Zurich and now a member of the faculty of the graduate school of the University of Pittsburgh and Research Engineer on the staff of the Research Laboratories of the Westinghouse Electric and Manufacturing Co. The President also stated that Doctor Nadai was the author of several books and a number of papers and qualified to the highest degree to address the Society as an Edgar Marburg Lecturer.

Doctor Nadai chose as the subject of his lecture "The Phenomenon of Slip in Plastic Materials," a subject on which he has carried out considerable research. He stated that in recent years it has been the aim of engineers to understand the causes for certain failures in mechanical constructions and the mechanism causing rupture in solid materials, and to have a better knowledge of the principal mechanical properties of matter in its solid state.

In his description of the plastic state of solids and of the modes in which solid metals flow, and in which solid rocks have apparently been severely deformed at great depths on a large scale in nature, he attempted to explain certain frequently observed phenomena which seem to be ultimately and intimately connected with plastic flow in metals. On polished metal or rock specimens subjected to severe stressing, faint traces of locally concentrated deformations in thin layers have been observed. In these thin layers, visible on the surface of a test specimen, frequently a pattern with an astonishingly regular symmetry may be seen. These regular markings or slip lines have proved extremely interesting both for the scientist, the engineer, and the mathematician. The strange laws have attracted recently the mathematicians since these regular markings might offer useful means to study the distributions of stress under which they were produced. In a great number of examples, taken from practical applications in engineering design and from the sciences of applied geo-physics and geology, the laws of the formation of the slip lines and of the plastic layers have been studied. He pointed out the mathematical analogy between the stress distribution in a plastic body when flow begins and the form of sand piles on irregular base surfaces. To demonstrate the fundamentals of the subject of his studies, he has perfected interesting equipment by means of which faint traces of plastic flow can be observed and deformed surfaces of metal specimens photographed.

President Mackenzie, in thanking Doctor Nadai for the excellent address, presented to him on behalf of the Society the Edgar Marburg Lecture Certificate.

The meeting then adjourned till 7 p. m.

WEDNESDAY, JUNE 24, 7 P. M.

Annual Meeting Dinner

Past-President H. F. Moore, Toastmaster and Presiding Officer.

The Toastmaster introduced Colonel Robert Isham Randolph, President of the Chicago Association of Commerce, who extended a very cordial welcome to the Society on the occasion of this first and very successful annual meeting in Chicago.

As spokesman for the business and professional interests of the City of Chicago, Colonel Randolph stated that the City was very happy to be the host of the Society on the occasion of its Thirty-fourth Annual Meeting and expressed a hope that the Society would hold subsequent meetings in Chicago and that they would continue to grow and prosper and be as successful as the present meeting.

The Toastmaster thanked Colonel Randolph for his address of welcome and then introduced the following guests at the speakers' table: H. H. Morgan, Chairman of the Chicago Committee; N. K. B. Patch, President of the American Foundrymen's Association; Dr. A. Nadai, the sixth Edgar Marburg Lecturer; F. D. Chase, President of the Western Society of Engineers; B. F. Affleck, Past-President of the Chicago Engineers Club; W. L. Abbott, Past-President of the American Society of Mechanical Engineers; and Cloyd M. Chapman, Vice-President of the Society.

The Toastmaster then presented President K. G. Mackenzie who delivered the annual Presidential Address, in which he reviewed briefly the progress of the Society during the past six-year period, and compared it with the six-year period immediately preceding. This comparison indicated that the Society must first of all extend the scope of its activities by creating new standing committees to cover those materials of engineering on which it is not now working, and also to increase the activities of present standing committees. This would result in an increased editorial burden for which secretarial assistance must be furnished. The regional meetings must be extended and eventually provision made for semi-annual meetings since the technical program that can be ably handled at one meeting is rapidly approaching the saturation point. All of which would contribute to a considerable increase in the publication program. President

Mackenzie also stated that the question of a monthly journal is one that would require consideration. To meet these needs there must be an appreciable increase in Society membership and sales of publications which can be accomplished only by the concerted efforts of all members.

The Toastmaster then recognized H. W. Gillett, member of the Committee on Award of the Charles B. Dudley Medal, who in the absence of the chairman, J. H. Gibboney, presented the recipient of the award for 1931. In presenting the recipient to President Mackenzie, Mr. Gillett made the following remarks:

> Mr. Toastmaster, ladies and gentlemen: I regret that the chairman of the committee, Mr. Gibboney, is unable to be present and so I have been asked to present the recipient. The award of the Dudley Medal is for a paper of outstanding merit as an original contribution on research in engineering materials. The members of this committee were evidently selected because their interests lay in such different fields that they were fairly conversant with the different activities of the Society. Each one of the three read all the thousand pages conscientiously. We met together and found on comparing notes that at the head of every one of the three lists was the same paper, one by Doctor Pfund, on "Hiding Power Measurements in Theory and Application."
>
> As our President has said, part of the activities of this Society is the making of specifications. I have watched the making of a good many specifications. A great many of them have a good deal of friction in the process of making; and there are a good many which we should be making and are not because we have a difficult time in drawing up a specification which is acceptable. When we cannot make a specification that we ought to make, it is because we do not know enough about the subject.
>
> A man who, in the course of years of professional experience, has been applying his theoretical knowledge to a practical end for the benefit of the Society and its membership, who is dispelling this lack of knowledge, who, years ago, as the committee found later when it looked into the matter, had already given a description of an embryonic form of apparatus which he described in this last paper, who described it so thoroughly, concisely and clearly that even to those of us on the committee who were not conversant with the subject, it was perfectly clear that this was an outstanding contribution to engineering research; we further found that several other papers in last year's Proceedings described Doctor Pfund's work as having brought order out of chaos.
>
> That is the sort of thing we need. The development of the quantitative instrumentation to give us new knowledge, and the application of theory to practice, are well exemplified in the paper by Doctor Pfund which we have recommended to the Society as entirely worthy of the Dudley Medal. I take great pleasure, on behalf of the committee, in presenting to you, President Mackenzie, Dr. A. H. Pfund.

On behalf of and as the representative of the Society, President Mackenzie then made the fifth award of the Charles B. Dudley Medal to Dr. A. H. Pfund, author of the paper entitled "Hiding Power

Measurements in Theory and Application" presented before the Society at the 1930 Annual Meeting and considered by the committee as a paper of outstanding merit constituting an original contribution on research in materials.

Doctor Pfund expressed his appreciation of the award, as follows:

> It is indeed a great honor to be awarded the Charles B. Dudley Medal by the American Society for Testing Materials, a Society whose noble purpose and high ideals are known the world over. I accept this medal in all humility and I shall cherish it and the memory of this occasion as long as I live.
>
> Since the Society is of necessity largely committed to a program of applied research, I cannot but make a few remarks in regard to this field of endeavor. Those who labor in the field of pure research are often inclined to place too great an emphasis upon the word "pure," so that by implication, other types of research become impure. Were one of a frame of mind to retaliate, one might with equal right speak of "applied" research whence, by inference, other types of research become misapplied. There is just enough truth on both sides to make this a dangerous subject of controversy. It is indeed foolish to attempt to pit one type of research against another. Much the happiest results are attained by a proper cooperation between the two. The triumphs of applied science are too obvious to require enumeration. As a result of these activities, this has become a better world to live in, human lives are happier, economic and sociological problems have been solved in a manner undreamed of. But quite apart from this, applied research plays a definite rôle toward pure research. It is well known that discoveries are frequently made as the result of bringing together conditions which have never before been realized. Something unexpected happens and some one in the neighborhood with sufficiently keen power of observation, sufficiently great versatility, recognizes that what is happening is new, and as a result, a discovery is made. Laboratory experiments are necessarily on a small scale, whereas operations in plants are usually on a tremendous scale, and the conditions which apply in these large scale operations are necessarily different from those which are met with in the laboratory. Therefore in regard to these large scale operations the stage is all set for the discoveries of which I have spoken. They have often been made but the underlying reason for these phenomena, and their explanation is often very difficult and their pursuit involves the purest of pure science.
>
> It is therefore evident that applied research and the problems it presents must have an important bearing upon pure research that cannot be overestimated.

The Toastmaster then recognized T. R. Lawson, chairman of the Committee on Tellers, who reported the results of the letter ballot on election of officers. Of the 1075 legal ballots cast, the results were as follows:

For President, to serve for one year: F. O. Clements, 1075 votes.

For Vice-President, to serve for two years: S. T. Wagner, 1075 votes.

For Members of Executive Committee, to serve for two years:
Arthur W. Carpenter, 1075 votes.
K. B. Cook, 1075 votes.
J. B. Johnson, 1075 votes.
G. C. D. Lenth, 1074 votes.
O. L. Moore, 1075 votes.

In accordance with the ballot the Chair declared the officers listed above elected.

The chairman then introduced the newly elected members of the Executive Committee.

The Toastmaster then introduced the Vice-President-Elect, S. T. Wagner, whom he described as one well-beloved by all members of the Society. Mr. Wagner earnestly thanked the members for the honor which they had conferred upon him in his election and stated that while he realized the office was one of responsibility he wished to express his assurance that he would do everything in his power to merit such confidence.

The Toastmaster then introduced the President-Elect, F. O. Clements, who expressed sincere appreciation of the honor of his election to the presidency. Mr. Clements reviewed briefly his personal experiences in the engineering profession and said it would be his aim to increase the activities of the Society in a number of new fields of endeavor that mean so much to modern civilization. He stated that he had been associated with and taken part in the activities of the Society for a number of years and was very much impressed with the manner in which the Society had developed and the valuable type of service it was rendering to industry. He valued particularly the cooperation with other national engineering societies as evidenced by the program of this annual meeting. He stated that he realized the obligations that the Presidency of the A.S.T.M. entailed and that he would do everything possible to further the interests of the Society. He also asked the continued cooperation of the membership especially along the lines, outlined in President Mackenzie's address, of increased membership, use and publicity of the Society's standards and in the activities of the standing committees.

As a pleasant surprise, the Toastmaster introduced Mr. Axel Christensen, who under the alias of Dr. Anton Carlson a noted Swedish metallurgist entertained with a number of humorous stories.

The dinner meeting then adjourned and was followed by an informal dance and smoker.

NINTH SESSION—THURSDAY, JUNE 25, 9.30 A. M.

On Corrosion and Fatigue of Metals

(Held Simultaneously with Tenth Session)

Mr. H. W. Gillett in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel, in the absence of the chairman, J. H. Gibboney, was presented by the vice-chairman, H. E. Smith. The committee also asked permission to publish a report of Subcommittee VI on Specifications for Metallic-Coated Products which covered revisions in certain specifications for galvanized wire under its jurisdiction and which it was intended to propose for adoption during the year. On motion, the report of the committee was adopted.

The report of the Sectional Committee on Zinc Coating of Iron and Steel was presented by the chairman, J. A. Capp. On motion, the report of the committee was accepted for publication.

A paper entitled "Oxygen as a Factor in Submerged Corrosion" by E. C. Groesbeck and L. J. Waldron, in the absence of the authors was presented by H. S. Rawdon and discussed.

A paper entitled "Accelerated Corrosion Test of Sprayed Molten Metal Coatings, Applied on Steel, in an SO_2-CO_2-Air Atmosphere" by Leopold Pessel was presented from manuscript by the author and discussed.

A paper entitled "Influence of Water Composition on Stress-Corrosion" by D. J. McAdam, Jr., in the absence of the author was presented from manuscript by H. S. Rawdon.

The report of the Research Committee on Fatigue of Metals was presented by the chairman, H. F. Moore. On motion, the report of the committee was accepted for publication.

A paper entitled "Fatigue Testing of Wire" by S. M. Shelton, in the absence of the author was presented by W. H. Swanger and discussed.

A paper entitled "A Seven-ton 50-cycle Fatigue Testing Machine" by B. P. Haigh and T. S. Robertson, in the absence of the authors was presented from manuscript by T. C. Tweedie.

A paper entitled "Fatigue Tests of Weld Metal" by R. E. Peterson and C. H. Jennings was presented by Mr. Peterson and discussed.

A paper entitled "Endurance Testing of Steel: Comparison of Results Obtained with Rotating Beam *versus* Axially Loaded Specimens" by R. D. France, in the absence of the author was presented from manuscript by W. H. Swanger and discussed.

The meeting then adjourned till 8 p. m.

TENTH SESSION—THURSDAY, JUNE 25, 9.30 A. M.

Symposium on Weathering Characteristics of Masonry Materials

(Held Simultaneously with Ninth Session)

Mr. T. R. Lawson in the chair.

The purpose of this symposium was to bring out available information on the weathering of masonry materials and to emphasize those phases which require further study and on which information is lacking.

A paper entitled "Economic Aspects of Masonry Decay from Weathering Effects" by H. S. Brightly was presented from manuscript by the author.

A paper entitled "The Performance of Concrete in Exposed Structures" by Ephrem Viens was presented by the author.

A paper entitled "The Weathering of Structural Clay Products: A Review" by J. W. McBurney was presented by the author.

The subject of weathering of stone and slate was covered in the following two papers:

"Weathering of Stone" by G. F. Loughlin—in the absence of the author presented from manuscript by H. S. Brightly;

"The Weathering of Slate" by C. H. Behre, Jr.—in the absence of the author presented by D. W. Kessler.

A paper entitled "Weathering of Aggregates" by L. O. Hanson was presented by the author and discussed.

The subject of weathering test procedures for various masonry materials was covered in the following papers:

"Test Procedures for Concrete" by F. H. Jackson—in the absence of the author presented by title;

"Test Procedures for Clay Products" by H. D. Foster—presented by the author;

"Test Procedures for Stone" by D. W. Kessler—presented by the author and discussed.

A bibliography with abstracts on weathering of masonry covering the following materials was presented by title:

"On Weathering of Concrete Masonry Units" by F. O. Anderegg;
"On Weathering of Natural Stone" by D. W. Kessler;
"On Weathering of Concrete" by F. R. McMillan;
"On Weathering of Structural Clay Products" by D. E. Parsons.

The meeting then adjourned till 8 p. m.

ELEVENTH SESSION—THURSDAY, JUNE 25, 8 P. M.

On the Economic Significance of Specifications for Materials

(Joint Session with Western Society of Engineers)

President Mackenzie extended a cordial welcome to the members of the Western Society of Engineers at this joint session of the W.S.E. and A.S.T.M. on "The Economic Significance of Specifications for Materials."

Mr. F. D. Chase, President of the Western Society of Engineers, was then introduced by President Mackenzie and in opening the meeting Mr. Chase expressed appreciation on behalf of the Western Society of Engineers for the opportunity of cooperating in this joint session held for the purpose of affording an opportunity for engineers and executives to discuss the significance and use of specifications. He paid a tribute to the work of the Society in improving and standardizing specifications for the large number of engineering materials. He pointed out that this standardization work is valuable because it promotes economy in industry, so vital in these times of business stress and industrial competition, and also because it improves the safety of human life as manifested by the improvements that are obtained by the proper specifications and standards and the intelligent use of materials and labor.

President Mackenzie then introduced Zay Jeffries, chairman of the joint session. Mr. Jeffries stated that the five speakers on the program would present the subject of significance of specifications in the production and use of steel and concrete, as well as the viewpoint of the purchaser of materials, and it was hoped that the discussion would bring out the value of the use of specifications by industry. He pointed out the need of a shorthand method of expressing and referring to specifications for most commodities. Mr. Jeffries then introduced the five speakers on the program who read the following papers:

"Value of Specifications in the Manufacture of Steel" by John Brunner, Manager, Department of Metallurgy and Specifications, Illinois Steel Co.

"The Economic Significance of Specifications for Materials from the Standpoint of a User of Steel" by P. Parke, Chief Engineer, The Pullman Co.

"The Use of Specifications from the Point of View of a Producer of Concrete" by J. P. H. Perry, Vice-President, Turner Construction Co.

"The Use of Specifications for Concrete from the Consumer Viewpoint" by A. R. Lord, President, Lord and Holinger, Architectural and Civil Engineers.

"Specifications from the Standpoint of a Large Purchaser of Engineering and Special Materials" by J. W. Bancker, Vice-President, Western Electric Co.

Following the presentation of these papers Mr. H. C. Mougey discussed the economic value of specifications for motor oils.

On motion by President Mackenzie a rising vote of thanks was accorded the authors of the papers for their very excellent presentations.

The meeting then adjourned till the following morning.

TWELFTH SESSION—FRIDAY, JUNE 26, 9.30 A. M.

On Non-Ferrous Metals, Metallography

(Held Simultaneously with Thirteenth Session)

Vice-President F. O. Clements in the chair.

The report of Committee B-2 on Non-Ferrous Metals and Alloys, in the absence of the chairman, William Campbell, was presented by the vice-chairman, W. H. Bassett. The proposed Tentative Methods of Chemical Analysis of Silver Solders were accepted for publication as tentative. On motion, the report of the committee was adopted.

The report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, in the absence of the chairman, C. H. Mathewson, was presented by W. H. Bassett. The report as preprinted contained proposed specifications for copper water tube, appended as information, which the committee recommended be withdrawn for further consideration. On motion, the report of the committee was adopted.

The following two papers on fatigue were presented:

"Fatigue Tests in Shear of Three Non-Ferrous Metals" by H. F. Moore and R. E. Lewis—presented by Mr. Lewis;

"The Static and Fatigue Properties of Brass" by J. B. Kommers —presented by the author.

The presentation of these papers was followed by a joint discussion.

The report of Committee E-4 on Metallography was presented by the chairman, C. H. Davis. On motion, the report of the committee was adopted.

The report of Committee B-7 on Light Metals and Alloys, Cast and Wrought, in the absence of the chairman, J. B. Johnson, was presented by the secretary, J. A. Gann. As preprinted, the report made reference to but did not include three proposed specifications, namely, Specifications for Aluminum Alloy Wire, Rods, and Bars, Specifications for Magnesium-Base Alloy Sheet and Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet), which specifications had been prepared by the committee and which it proposed to submit for publication as tentative. These specifications covered material which involved patents and they accordingly have been referred to the Executive Committee and their submission for publication as tentative is contingent on their approval by that committee. The specifications were, therefore, not presented with the report pending their approval by the Executive Committee, after which they will be presented to the Society through Committee E-10 on Standards.[1]

The proposed revision of the Tentative Specifications for Magnesium-Base Alloy Castings (B 80 – 30 T) was accepted, subject to favorable approval by letter ballot of the committee[2], the specifications as revised being continued as tentative.

The advancement to standard of the Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet (B 78 – 30 T), for Aluminum-Manganese Alloy Sheet (B 79 – 30 T), for Aluminum-Base Alloy Castings (B 26 – 30 T), as revised, and for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T), as revised, was approved for reference to letter ballot of the Society for adoption, subject to approval by letter ballot of the committee.[3] On motion, the report of the committee was adopted, subject to a favorable letter ballot of Committee B-7.[4]

The report of Committee B-6 on Die-Cast Metals and Alloys was presented by the chairman, H. A. Anderson and discussed. The proposed Specifications for Aluminum-Base Alloy Die Castings and for Zinc-Base Die Castings were accepted for publication as tentative. In presenting the report Mr. Anderson called on F. J. Tobias to present his paper "Lead-Base and Tin-Base Alloys for Die Castings" appended to the report and on D. L. Colwell to present his paper "Effect of Composition on Aluminum-Base Die-Casting Alloys" appended to the report. The paper by Mr. Colwell was then discussed. On motion, the report of the committee was adopted.

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[1] The necessary information concerning these specifications has not yet been obtained so their consideration by the Executive Committee and Committee E-10 on Standards has accordingly been delayed and the specifications have not been accepted for publication.—ED.

[2] The specifications were submitted to letter ballot of the committee which consists of 28 members; 18 members returned their ballots of whom 13 have voted affirmatively and none negatively.

[3] The letter ballot on these specifications resulted as follows: Tentative Specifications for Aluminum Alloy (Duralumin) Sheet (B 78 – 30 T) and Specifications for Aluminum-Manganese Alloy Sheet (B 79 – 30 T), 15 affirmative, none negative and 3 members not voting; Tentative Specifications for Aluminum-Base Alloy Castings (B 26 – 30 T) and Specifications for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T), 17 affirmative, none negative and 1 member not voting.

[4] The report was submitted to letter ballot of the committee which consists of 28 members; 18 members returned their ballots of whom 17 have voted affirmatively and none negatively.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was presented by the chairman, T. S. Fuller. On motion, the report of the committee was adopted.

The report of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys was presented by the chairman, Dean Harvey. The proposed Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements; Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, Balance Iron, for Electrical-Heating Elements; and Method of Test for Determining the Temperature-Resistance-Constants of Resistance Alloys were accepted for publication as tentative. On motion, the report of the committee was adopted.

The meeting then adjourned till 2 p. m.

THIRTEENTH SESSION—FRIDAY, JUNE 26, 9.30 A. M.

On Masonry Building Materials, Refractories

(Held Simultaneously with Twelfth Session)

President K. G. Mackenzie in the chair.

The report of Committee C-3 on Brick in the absence of the chairman, H. T. Shelley, was presented by the secretary, J. W. McBurney. The advancement to standard of the Tentative Methods of Testing Brick (Compression, Flexure and Absorption) (C 67 – 30 T) was approved for reference to letter ballot of the Society for adoption. On motion, the report of the committee was adopted.

The report of Committee C-8 on Refractories in the absence of the chairman, G. A. Bole, was presented by J. R. Allan. The recommendation of the committee that the modulus of rupture or flexural strength test described in the Tentative Methods of Testing Brick (C 67 – 30 T) developed under the jurisdiction of Committee C-3 on Brick be used in testing refractories was accepted. The proposed revisions of the Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 20) and of the Test for Softening Point of Fire-Clay Brick (C 24 – 28) were accepted for publication as tentative. The proposed revision of the Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 27 T) was accepted, the method as revised being continued as tentative.

The advancement to standard of the tentative definitions of the terms "spalling" and "pyrometric cone equivalent" appearing in the

Tentative Definitions of Terms Relating to Refractories (C 71 – 30 T) was approved for reference to letter ballot of the Society for adoption. As preprinted the report recommended that the list of terms relating to heat transmission of refractories appearing in the Tentative Definitions of Terms Relating to Refractories (C 71 – 30 T) be advanced to standard, but after further consideration the committee recommended that these definitions be continued as tentative.

The advancement to standard of the tentative revision of the Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 28) was approved for reference to letter ballot of the Society for adoption. On motion, the report of the committee was adopted.

A paper entitled "Comparative Tests for Determining Resistance of Fire-Clay Brick to Thermal Spalling" by R. A. Heindl was presented by the author and discussed.

The report of Committee C-10 on Hollow Masonry Building Units was presented by the chairman, D. E. Parsons. The revisions proposed for immediate adoption in the Standard Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 – 30), for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 – 30), for Hollow Burned-Clay Floor Tile (C 57 – 30) and in the Definitions of Terms Relating to Hollow Tile (C 43 – 24) were unanimously approved for reference to letter ballot of the Society for adoption as standard, this recommendation requiring a nine-tenths vote. On motion, the report of the committee was adopted.

The following papers on masonry and concrete units were presented:

"Specifications for Hollow Masonry Building Units" by D. E. Parsons—presented by the author;

"Tests of the Stability of Concrete Masonry Walls" by F. E. Richart, P. M. Woodworth and R. B. B. Moorman—presented by Mr. Richart;

"Tests of the Fire Resistance and Stability of Walls of Concrete Masonry Units" by C. A. Menzel—presented by the author.

The presentation of these papers was followed by discussion.

The report of Committee D-16 on Slate in the absence of the chairman, W. B. Plank, was presented by D. W. Kessler. The advancement to standard of the Tentative Method of Test for Water Absorption of Slate (D 221 – 27 T), as revised, and the Methods of Flexure Testing of Slate (Determination of Modulus of Rupture and Modulus of Elasticity) (D 222 – 27 T), as revised, was approved for reference to letter ballot of the Society for adoption. On motion, the report of the committee was adopted.

The report of Committee D-18 on Natural Building Stones in the absence of the chairman, F. Y. Joannes, was presented from manuscript by the secretary, H. S. Brightly. On motion, the report of the committee was adopted.

The meeting then adjourned till 2 p. m.

FOURTEENTH SESSION—FRIDAY, JUNE 26, 2 P. M.

On Cast Iron; Symposium on Malleable Iron Castings

(Joint Session with American Foundrymen's Association)

(Held Simultaneously with Fifteenth Session)

Past-President J. A. Capp in the chair.

The report of Committee A-3 on Cast Iron was presented by the chairman, Hyman Bornstein. The advancement to standard of the tentative revision of the Standard Specifications for High-Test Gray-Iron Castings (A 88 – 29) was approved for reference to letter ballot of the Society for adoption.

Mr. Bornstein then presented his paper entitled "A Comparison of Various Sizes of Test Bars Representing Cast Irons from Five Foundries" appended to the report. Another paper appended to the report entitled "Tests on Cast-Iron Specimens of Various Diameters" by J. T. MacKenzie was presented by the author. On motion, the report of the committee was adopted.

A paper entitled "Shear Test for Cast Iron" by H. H. Judson was presented from manuscript by the author and discussed.

The report of Committee A-7 on Malleable Castings was recommended by the chairman, W. P. Putnam, to be withdrawn. The committee had prepared proposed revised specifications for malleable castings for acceptance by the Society as tentative, but due to objections that had developed the committee had voted unanimously for the withdrawal of the report.

The Chair then recognized President Mackenzie who extended a cordial welcome to the members of the American Foundrymen's Association who, together with the Society, was sponsoring the Symposium on Malleable Iron Castings.

President Mackenzie introduced the president of the American Foundrymen's Association, N. K. B. Patch, who in opening the symposium spoke of the value of cooperation between two great national societies such as the American Foundrymen's Association and the American Society for Testing Materials, stating that the holding of this symposium is a step in the right direction toward the spreading of valuable knowledge among those who use the materials, design, and manufacture malleable castings. Mr. Patch said further that the sponsoring of such a symposium entailed an obligation to give information without stint, without taint of personal feeling or advertising personal interests and to leave for posterity a creditable picture to look back upon when this work is reviewed in subsequent years.

This Symposium on Malleable Iron Castings is the first of several that have been planned by the American Foundrymen's Association and the American Society for Testing Materials for the purpose of providing the engineering profession with authoritative data in concise form on the properties of metal castings produced by the best present methods of production. In addition to malleable castings it is planned to cover in subsequent similar symposiums, steel castings, both carbon steel and alloy steel, gray-iron and other iron castings, and castings of various non-ferrous metals. The committee under the chairmanship of the Secretary-Treasurer, C. L. Warwick, was appointed by the two societies to compile, critically analyze and assemble for publication, data on the properties of malleable iron castings useful to engineers and metallurgists engaged in designing and specifying such castings. Many sources were consulted and every effort made to make the compilation as complete and authoritative as possible.

W. P. Putnam then presented a summary of the first three items of the symposium, namely, Introduction, Manufacture of Malleable Iron Castings, and Properties of Malleable Iron, the latter subject including chemical composition, physical constants, mechanical properties, electrical and magnetic properties, machinability, microstructure and heat treatment.

H. A. Schwartz presented the fourth part of the symposium, namely, Supplementary Data and Discussion of Tensile Properties.

Enrique Touceda presented the following subjects: Higher Strength Malleable Iron, Cupola Malleable Iron and Necessity for Cooperation Between Engineer-Designer and Foundry.

A paper entitled "An Investigation of Methods to Determine the Machinability of Malleable Iron Castings" by O. W. Boston was presented from manuscript by the author.

A paper entitled "Corrosion of Malleable Iron" by F. L. Wolf and L. A. Meisse was presented by Mr. Wolf.

The presentation of the above was followed by discussion.

The meeting then adjourned till 8 p. m.

FIFTEENTH SESSION—FRIDAY, JUNE 26, 2 P. M.

On Cement and Concrete, Lime, Gypsum

(Held Simultaneously with Fourteenth Session)

Mr. F. H. Jackson in the chair.

The report of Committee C-7 on Lime was presented by the chairman, H. C. Berry. The advancement to standard of the tentative revision of the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 24) was approved for reference to letter ballot of the Society for adoption. The proposed revision of the Tentative Specifications for Sand for Use with Lime Plaster (C 66 – 27 T) was accepted, the specifications as revised being continued as tentative. On motion, the report of the committee was adopted.

The report of Committee C-11 on Gypsum in the absence of the chairman, J. W. Ginder, was presented by the secretary, H. J. Schweim.

The proposed revisions of the Standard Specifications for Gypsum Plaster Board (C 37 – 30), for Gypsum Wall Board (C 36 – 25), in the form of new tentative specifications, and the proposed revision of the Standard Methods of Testing Gypsum and Gypsum Products (C 26 – 30) were accepted for publication as tentative.

The proposed revision of the Tentative Specifications for Gypsum Sheathing Board (C 79 – 30 T) and of the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 29 T) were accepted, the specifications and definitions as revised being continued as tentative. On motion the report of the committee was adopted.

The report of Committee C-1 on Cement was presented by the chairman, P. H. Bates and discussed. In presenting the report the chairman recommended the addition of a paragraph that had been approved by the committee with reference to the temperature of cement and its effect upon the temperature of the concrete. On motion, the report of the committee was adopted.

A paper entitled "Crystalline Talc as an Admixture in Concrete" by F. R. Wicks was presented by the author and discussed.

At this point the program was interrupted for the presentation of the golf and tennis prizes. The winners were announced and the prizes awarded by E. D. Boyer on behalf of the chairman of the Entertainment Committee, H. H. Morgan. The A.S.T.M. Championship Golf Cup for low score was won for the third time by H. G. Farmer of the Universal Atlas Cement Co. The A.S.T.M. Championship Tennis Cup was also won for the third time by F. S. Crane of the Illinois Steel Co.

Other prize winners in the golf and tennis tournaments were: F. G. Carrell, H. B. Emerson, H. P. Bigler, C. A. Plaskett, C. E. Hoyt, J. C. Haswell, W. M. Kinney, M. A. Swayze, E. M. Lurie, G. W. Huchinson, Robert Glenn and G. C. Wilsnack.

The program then continued with the presentation of a paper entitled "The Concrete Flow Trough" by D. M. Burmister—presented by the author and discussed.

The meeting then adjourned till 8 p. m.

SIXTEENTH SESSION—FRIDAY, JUNE 26, 8 P. M.

On Concrete

Vice-President Cloyd M. Chapman in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates, Cloyd M. Chapman, chairman, was presented by the secretary, Stanton Walker. The proposed Tentative Specifications for Curing Portland-Cement Concrete, for Curing Portland-Cement Concrete Slabs with Bituminous Coverings, for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture, for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride, for Curing Portland-Cement Concrete Slabs with Wet Coverings and Tentative Methods of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar, Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition and Routine Analysis of the Cement Content of Hardened Portland-Cement Concrete were accepted for publication as tentative.

The proposed revision of the Tentative Specifications for Concrete Aggregates (C 33 - 30 T) was accepted, the specifications as revised being continued as tentative.

The advancement to standard of the tentative revision of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 - 27) was approved for reference to letter ballot of the Society for adoption.

The report as preprinted recommended for publication as information a revision in the Standard Methods of Securing Specimens of Hardened Concrete from the Structure (C 42 - 27). The committee recommended that this proposed revision be adopted immediately subject to approval by letter ballot vote of the committee and on motion the revision was unanimously approved for reference to letter ballot of the Society for immediate adoption, subject to a favorable letter ballot of Committee C-9,[1] this recommendation requiring a nine-tenths vote.

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[1] The letter ballot on the revision of these methods resulted as follows: 41 affirmative, 2 negative, with 2 members not voting.

In presenting this extensive report the secretary reviewed rather briefly the activities of the various subcommittees and called attention to the fact that the report contained results of work on a number of important problems some of which have been receiving careful attention for several years past but had not until now reached the stage of completeness which would permit the results being published. The secretary called upon the various subcommittee chairmen and authors to present their individual reports and papers, appended to the report, as follows:

Report of Subcommittee XIII on Curing of Concrete—presented by the chairman, R. W. Crum;

"Digest of Available Information on the Use of Calcium Chloride for Curing Concrete" by H. S. Mattimore and H. H. Miller—presented by title;

"Digest on Effect of Curing Methods on Strength of Concrete" by F. C. Lang—presented by title;

"Pavement Core-Drilling Practice" by L. W. Teller and P. J. Freeman—presented by title;

"A Study of the Analysis of Fresh Concrete" by W. M. Dunagan —presented by the author and discussed;

"Determining the Cement Content of Set Concrete by Chemical Methods of Analysis" by H. F. Kriege—presented by title;

"The Effect of Aggregate and Other Variables on the Elastic Properties of Concrete" by P. M. Noble—presented by the author and discussed;

"Suggested Terminology Applying to the Study of Concrete Structures in Service" by F. R. McMillan—presented by title.

On motion, the report of the committee was adopted.

A paper entitled "Accelerated Freezing and Thawing as a Quality Test for Concrete Aggregates" by F. C. Lang and C. A. Hughes was presented by Mr. Lang and discussed.

A paper entitled "Studies of Paving Concrete" by F. H. Jackson and W. F. Kellermann was presented from manuscript by Mr. Jackson and discussed.

An informal report of progress of the activities of the Society's representatives on Joint Committee on Standard Specifications for Concrete and Reinforced Concrete was presented by the chairman, Cloyd M. Chapman. Mr. Chapman outlined the reorganization of the committee and plans for revision of the present specifications.

A paper entitled "Tests of Concrete Conveyed from a Central Mixing Plant" by W. A. Slater was presented by the author and discussed.

A paper entitled "Temperatures Developed in Mass Concrete and Their Effect upon the Compressive Strengths" by R. E. Davis and G. E. Troxell was presented by Mr. Davis and discussed.

A paper entitled "The Effect of Time Loading upon the Bond Stress Between Concrete and Steel" by R. L. Brown and E. C. Clark was presented from manuscript by Mr. Brown and discussed.

President Mackenzie then assumed the Chair and in closing the annual meeting extended a vote of thanks to W. L. Abbott, Past-President of the American Society of Mechanical Engineers, F. D. Chase, President of the Western Society of Engineers and N. K. B. Patch, President of the American Foundrymen's Association for their splendid cooperation in making the Thirty-fourth Annual Meeting the most successful one yet held by the Society. He also expressed appreciation for the very excellent work done by the Local Chicago Committee under the chairmanship of H. H. Morgan. The Robert W. Hunt Co. and the Inland Steel Co. who so kindly furnished the lanterns and operators for the sessions were also given a vote of thanks for their cooperation. President Mackenzie called attention to the manifest and divers activities of the Society and their complexity and moved a vote of appreciation to the Secretary-Treasurer, Assistant Secretary, Assistant Treasurer and all members of the Society Headquarters' Staff for their untiring labors during the past year.

President Mackenzie in announcing the registered attendance as 1451, which exceeded all previous records for attendance at preceding annual meetings, pointed out that this did not include the members of the Western Society of Engineers who were guests at the session on significance of specifications nor the more than 140 persons registered as exhibitors or connected with the exhibit which would increase the total number attending the meeting.

There being no further business, President Mackenzie declared the Thirty-fourth Annual Meeting adjourned *sine die.*

OUR SOCIETY

ANNUAL ADDRESS BY THE PRESIDENT

K. G. MACKENZIE

JUNE 24, 1931

"Due to the fact that we have testing laboratories of our own we regret that we will be unable to utilize the facilities of your Society."

This statement was received from responsible officers of two large corporations in reply to a suggestion that they would find membership in our Society of considerable value. Such is fame!

Our charter states clearly that the purpose of our Society is the promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing. Certainly no statement of purpose and scope could be clearer and yet it is distressing to find how many, even of our own members, have an erroneous conception of our field of activity. Many times have I heard it said that the function of our Society is the preparation of specifications and methods of testing; that we are neither authorized nor supposed to engage in research work. If we for a moment disregard that function of the Society dealing with the promotion of knowledge of the materials of engineering and limit our consideration solely to the standardization of specifications and methods of testing, we shall see that even here we cannot escape research.

It is quite possible that in the early days of our Society, standardization of methods of testing was more or less restricted to the revision and refinement of existing methods to that degree which is necessary to give concordant results, and that also the earlier specifications were prepared from accumulated experience which indicated the properties necessary for certain materials. We have long since, however, passed that stage.

Methods must indicate the behavior of the material in service. This often requires very extensive research. As an example, I would mention the work of the Subcommittee on Turbine Oils of Committee D-2 on Petroleum Products and Lubricants. This subcommittee is attempting to determine the relation between certain proposed laboratory tests and actual performance in steam turbines over long periods of time, a research program of considerable magnitude.

The limits to be set by specifications to insure a satisfactory product also require research, even where there may be no question of the general significance of the method. As an illustration, we now have the problem before Technical Committee A on Gasoline of Committee D-2, of deciding on the maximum sulfur content which should be permitted in gasoline. This can be solved only by extensive research involving a study of the effects of different percentages of sulfur in gasoline upon different types of engines under different conditions.

When we come to our other function, the promotion of knowledge of the materials of engineering, we find that such promotion may be accomplished by:

(*a*) Research in the Society, either in standing committees dealing with the specific materials, or under the auspices of our Committee E-9 on Correlation of Research.
(*b*) Publication of research by others.
(*c*) Extending the usefulness of existing information.

We are this week holding our thirty-fourth annual meeting, and our thirtieth meeting since incorporation of our Society. We naturally view with pride our increase in membership from 175 in 1902 to 4327 in 1931. The work of our standing committees is to my mind without parallel in the history of technical organizations. It has often been said that in no other society do the members contribute as much as in our own. The work of our 50 standing committees with a membership of approximately 2500 is well reflected in our 584 standards and tentative standards comprising 2816 pages. Our committee reports alone last year totalled 883 pages, and our technical papers, which you will recall provide one of the media through which we promote the knowledge of materials of engineering, amounted in the year 1930 to over 1000 pages. We also again consider with considerable satisfaction our income last year of over $120,000 from dues and sale of publications alone.

In extending the usefulness of our work we are gratified to see that in the American Standards Association of all the standards adopted (with the exception of those in the so-called Public Safety Group) one-third are the standards of our Society, and that of the various projects coming under the American Standards Association, one-fourth are sponsored either solely or in part by our Society.

However, gratifying as these figures may be, they are apt to be misleading.

In 1925 President Farmer, in his annual address, reviewed some of the activities of our Society and stressed our needs for the coming years. Six years have now passed, and it would seem appropriate to pause a moment to review our progress during this period in comparison with the six-year period immediately preceding it.

Standards:

Our standards and tentative standards for the years in which the triennial book of standards has been issued for these periods are as follows:

INCREASE IN STANDARDS AND TENTATIVE STANDARDS

YEAR	NUMBER	PAGES	YEAR	NUMBER	PAGES
1918	177	1031	1927	515	2432
1921	287	1349	1930	584	2816
1924	405	1863			

While in total pages the last six years gave an increase of 953 against 832 for the preceding six-year period, the number of standards in 1930 was only 179 more than 1924, whereas in that year we exceeded 1918 by 228. This does not indicate any diminution of activities on the part of our standing committees, it does show that we have not been extending the field of our committee work.

Standing Committees:

This is further borne out by the increase of our committees both in number and total membership:

GROWTH OF STANDING COMMITTEES

YEAR	NUMBER	TOTAL MEMBERSHIP	YEAR	NUMBER	TOTAL MEMBERSHIP
1919	38	1132	1926	45	2083
1920	40	1284	1927	45	2184
1921	40	1325	1928	45	2178
1922	39	1525	1929	49	2342
1923	40	1606	1930	50	2498
1924	42	1772	1931	50	2500
1925	43	1946			

Our standing committees in total number show a consistent growth in each period. Increase in membership 1919 to 1925 was 814; the following six-year period only 554. This, however, is as it should be. We cannot make our standing committees too large in membership. The comparison does indicate, however, that we have not extended our field of activities in materials of engineering as we should. While I am glad to be able to report that we have three new standing committees in the course of organization, we will nevertheless admit that there are many lines which we have not as yet touched.

Committee Reports:

Our committee reports for the period 1919 to 1924 averaged 446 pages; for the period 1925 to 1930 averaged 577:

VOLUME OF COMMITTEE REPORTS

YEAR	NUMBER OF PAGES	YEAR	NUMBER OF PAGES
1919	289	1925	437
1920	372	1926	520
1921	379	1927	543
1922	479	1928	616
1923	459	1929	465
1924	698	1930	883

The number of pages indicated does not include the standards presented by the committees. While this indicates a growth in the research activities of our committees we should not be satisfied, but we should increase these activities.

It should be mentioned that all data in respect to number of pages are in terms of pages as printed, no account having been taken of an increase in type page size made in 1921 or of the use of smaller size type for certain portions of reports, papers and standards which results on the average in each page representing perhaps 20 per cent more material in recent years over that ten years ago. This affects more particularly the statistics on volume of report and papers material. However, this does not change the general significance of the data.

Technical Papers:

Again in our technical papers the average number of pages for the period 1919 to 1924 was 659, while for the following six years the average was only 758:

VOLUME OF TECHNICAL PAPERS

YEAR	NUMBER	TOTAL PAGES	YEAR	NUMBER	TOTAL PAGES
1919	29	786	1925	26	437
1920	28	495	1926	48	668
1921	24	332	1927	33	542
1922	38	575	1928	46	874
1923	52	662	1929	58	983
1924	49	1104	1930	76	1046

This does not mean that valuable material was not available for publication, since every year excellent papers have to be rejected by our Committee E-6 on Papers and Publication, due to budget limitations.

Our Future Needs:

We must first of all extend the scope of our activities. We must create new standing committees to cover those materials of engineering on which we are not now working. We must shortly give some assistance to at least our larger standing committees. Where a standing committee has over 100 members, the routine secretarial work alone is a large task. This in most cases has been assumed and financed by either the corporation or association with which the secretary of the committee is connected. Such a condition cannot continue indefinitely. We must be able, in the future, to supply at our headquarters secretarial assistance to our standing committees.

We must extend our regional meetings. All of our members cannot attend our annual meetings. These regional meetings provide the desirable contacts of the annual meeting even though on a smaller scale. We must publish the papers presented at our regional meetings and some of these papers should be included in our Proceedings.

An examination of our program reveals that we are rapidly approaching the saturation point in material which can be ably handled at one meeting. We are consequently confronted with the question of semi-annual meetings, with a considerable increase in our publication program.

The question of a monthly journal, dealing with materials of engineering, and published by our Society, is one that has received consideration only with considerable trepidation. President Farmer believed that it was possible and desirable, and I agree with him without reservation. We are all proud of our annual volumes of Proceedings. We all know that they contain very valuable material, but most of us, I am afraid, when we receive them the latter part of each year, place them aside with the very excellent resolution that we will read them as soon as we have time. This was forcibly impressed upon me recently in my own organization. A report made use of a very valuable paper presented at our last annual meeting. This report did not refer to the paper as appearing in the *Proceedings* of the American Society for Testing Materials but gave reference to a publication of which I had never heard, but which presumably had reprinted it. We must admit that we are all more likely to read, or at least skim over, articles which are brought to our attention monthly, than to attempt to read a volume of 1000 pages. This, I feel, is appreciated by authors, and the average author realizes that he receives much greater recognition for this work if it appears in a technical journal of high standard than if it is simply published in the bound proceedings of some society. Possibly a monthly journal is still far in the future—eventually it must come.

In addition to the research work necessarily carried on by our many standing committees dealing with specific materials, there are certain research problems of more general nature which should be handled by our Committee E-9 on Correlation of Research. For research work of this nature we have available the income from a fund of $8387.85—not sufficient to cover a single problem with one worker at some university or technical school. There is work to be done We should do it.

We must increase the activities of our present committees and we must create new standing committees resulting in an increased burden on our headquarters staff. We must provide secretarial assistance to our standing committees. We must extend our regional meetings. We must provide eventually for a semi-annual meeting. We must increase our publication program. We must carry on research under the supervision of Committee E-9. How can we meet these needs?

Finances:

Our income in 1930 was divided approximately as follows:

Dues	65 per cent
Sale of Publications	26 "
Advertising, Income from Investments and Miscellaneous	9 "

This income in turn was spent as follows:

Printing	52 per cent
Overhead	39 "
Miscellaneous	9 "

It will be noted that our income is secured almost entirely from the sale of our publications, and dues:

INCOME FROM DUES AND SALE OF PUBLICATIONS

YEAR	DUES	PUBLICATIONS	YEAR	DUES	PUBLICATIONS
1918	$31 885.87	$7 122.84	1925	$56 591.36	$33 631.00
1919	35 249.20	9 302.49	1926	60 932.61	26 479.40
1920	39 997.47	10 983.37	1927	66 507.33	32 461.83
1921	42 505.33	18 003.56	1928	83 025.60	29 840.96
1922	44 062.32	18 258.83	1929	86 525.85	27 840.79
1923	48 784.52	22 024.90	1930	86 106.23	34 607.96
1924	52 576.62	20 514.30			

It will be seen that from 1918 to 1924 the receipts from sales of publications increased $13,391.46; from 1924 to 1930 the increase was $14,093.66. However, the increase of 1930 over 1927 was approximately only $2000. If additional income is to be secured from the sale of our standards, we must promote the use of these standards. The letters from the two companies, referred to in opening, are but an indication of how little is still known of our Society and its work.

Our standards in their preparation have involved an enormous expenditure of time and money on the part of our standing committee members. President Farmer in 1924 estimated that the total cost of the work of the Society to industry was in the order of $325,000 a year, and this has necessarily increased to a considerable degree since that date. Those of us who are in the position of both producer and consumer of engineering materials are naturally more interested in the materials we produce, and since we have had for a long period a buyers' market, I fear that we too often as buyers take the position that we will demand what we think we want, and the manufacturer must comply with our wishes. This was forcibly impressed on me a few months ago by a friend of mine in the steel industry who complained bitterly that the petroleum industry was not sold on our Society, whereas the steel industry was absolutely sold. I was rather surprised, since the work of Committee D-2 has, I believe, received as general acceptance by producers and consumers as any group of standards of the Society. He said, "But, the petroleum industry has not whole-heartedly accepted the A.S.T.M. standards for steel; the steel industry has accepted them 100 per cent." When I asked the extent of the use of the standards of our Society covering materials which the steel industry buys, he admitted that even this industry was possibly not 100 per cent sold.

As producers we are vitally interested in standardization; it simplifies manufacture and reduces stocks and inventories. This naturally benefits not only ourselves but also the consumers of our products, and we are not hesitant in urging upon the consumers the value of standardization and its financial return to them. Such standardization certainly is just as valuable to us in the case of the materials which we purchase, and if we would as diligently urge the use of our Society's standards when we buy, as we now urge their use when we sell, we would accomplish much toward the increased use of the standards.

This increased use of our standards will result in:

1. More sales;
2. Greater interest in the work of the Society; and, as a result,
3. More members.

Our major source of income is from dues. The increase of $33,000 in 1930 over 1924, compared with an increase of $21,000 in 1924 over 1918 is apt to be misleading. In 1928 we raised the so-called company dues from $15 to $30 a year, and this is largely responsible for an increase in that year of $16,500 over 1927. Our receipts from dues for 1930 was $3181.63 greater than in 1928 and $419.62 less than in 1929.

Membership:

This brings me to the question of membership:

INCREASE IN MEMBERSHIP

YEAR (AS OF JUNE 1)	NUMBER	YEAR (AS OF JUNE 1)	NUMBER
1919	2481	1926	4000
1920	2754	1927	4220
1921	2908	1928	4192
1922	3030	1929	4244
1923	3240	1930	4355
1924	3481	1931	4327
1925	3716		

From the year 1919 to 1925 our membership increased 1235. From the year 1925 to 1931, the increase was only 611. Up until the year 1928 every year showed an increase. In that year the increase in corporate membership dues resulted in a decrease of 28, but a large increase in the total amount received from dues. Our membership, however, as of June 1, 1931, is 28 less than the membership one year ago. I know it will be said that we are passing through a period of severe depression. My older friends who have weathered many depressions tell me that each depression always seemed much worse than any preceding it. We must not forget that we passed through another depression in 1921 and 1922, but without an actual decrease in membership. Had it not been for the very able work of our Committee on Membership, with the untiring efforts of its members, our losses would have been much greater.

Our total income from investments for the year of 1930 amounted to only $3650.78. There is furthermore, somewhere a limit in the volume of sales of our publications. Our future welfare must depend on an increase of membership. Our Secretary-Treasurer has estimated for me that if our income from dues can be increased $80,000, the increased expense to the Society for overhead, printing, etc., on the basis of our present publication program would amount to only $40,000, leaving $40,000 available for the promotion of those needed activities which we have already considered. The class of sustaining membership brought up for approval at this meeting will eventually provide some increase of income, but it will not be sufficient. The question which then confronts us is, have we reached the saturation point in membership? Our membership statistics of recent years would seem to support this view. I believe that such a view is not well founded. I believe that there is a large field for increase of our membership not only among those organizations and individuals not now holding membership in the Society but also in those corporations whose interest in our Society has heretofore been confined largely along the lines of the products they manufacture. But this increase can be accomplished only by the concerted efforts of all our members. Our Membership Committee has accomplished much. With our support I feel there is no limit to which its activities may extend.

Student Membership:

It may not be amiss at this point to mention our student membership. On June 1, 1930, we had 249—on June 1, 1931, we had 211. Our transfer from student to junior membership is six per cent, which compares very favorably with the experience of other technical societies. I have always viewed student membership, however, not as much as additional income to the Society, or the securing of junior members on the graduation of the students, but as an educational campaign. If, through student membership, students become familiar with the work of the Society and its scope, they will in their activities after graduation know that the Society is the source of information on the knowledge of the materials of engineering and specifications and the methods of testing; they will turn to the Society for this information and eventually become members. From this standpoint the student membership is of the most vital importance, and yet I am sorry to say that of our 211 student members, 121 come from one institution.

Contacts with Universities and Technical Schools:

Many of our members have, I feel sure, contacts with their respective Alma Mater which will enable them to stress to the faculties the importance of the work of the Society and of student membership. However, we must realize that as a society, we are working at a disadvantage compared with certain other technical organizations having local student chapters. We cannot offer this incentive to membership. We can, however, be impressing upon the faculties the importance of the work of the Society, at least secure promulgation of the Society's activities to the students so that if they do not become student members, they will at least learn of the Society and its work.

A year ago I called attention to the fact that a Society is a voluntary organization of individuals banded together for the common purpose of securing results of mutual benefit which could not be secured without this organization. We are members of our Society primarily for what we can give, rather than for what we can get. At times in the past have we heard from our members that *the* Society is not accomplishing what *it* should; that *it* is not functioning as *it* should; that it is neglecting activities which *it* should initiate. I am saying this advisedly, with full appreciation of the very loyal and unselfish work of our members. The cooperation, aid and assistance which the members have given the officers of the Society during the past year has been a constant source of inspiration. I believe we can go still farther.

I can express no greater hope for my successor than that he may in his administration, receive this cooperation to an even greater extent, and that there may be a fuller realization that we alone, as members, are responsible for the success of our Society.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee offers the following report of general Society activities for the year ending with this annual meeting:

Membership:

The membership of the Society on June 1, 1931, was 4327, compared with the corresponding membership a year ago of 4355. Statistics are shown in the following table:

Class of Members	Membership		Losses				Additions		Total		
	June 1, 1930	June 1, 1931	Resignations	Dropped	Death	Transfer	Transfer	Election	Loss	Gain	Increase
Honorary	4	4	...	...	..	..	..	..	..	..	..
Life or Perpetuity	11	11	...	..	..	..	..	..	..	..	..
Company, Firm, etc	1175	1124	77	30	..	9	3	62	116	65	51[a]
Individual, etc	3090	3102	146	100	26	3	28	259	275	287	12
Junior	75	86	6	5	..	19	..	41	30	41	11
Total	4355	4327	229	135	26	31	31	362	421	393	28[a]
Student	249	211	16	90	..	9	..	77	115	77	38[a]

[a] Decrease.

Although there has been a net increase of 12 in the class of individual members and 11 junior members, there has been a net loss in company membership of 51, making a net loss for the period of 28. This is undoubtedly a reflection of the present industrial conditions, which have not only resulted in a relatively greater number of resignations and delinquencies but at the same time a somewhat smaller number of new members elected during the year, which was 362 compared to 430 for the preceding year. The membership growth from the beginning of the Society's history appears in Fig. 1.

The Society has suffered the loss by death of the following 26 members:

	DATE OF MEMBERSHIP
Brookby, Harry E	1928
Burr, Henry Amsden	1928
Clemens, Henry M	1921
Downie, Ralph Waldo	1921
Edwards, James H	1928
Gahagan, Walter H	1921
Holmes, Carroll O	1928
Jones, George W	1925
Joseph, J. G	1912
Kier, P. S	1916
Koch, William C	1922

MacKay, H. M	1908
McGuire, James C	1907
Moldenke, Richard	1896
Nicholson, W. J	1924
Parr, S. W	1908
Shaw, Walter R., Jr	1931
Smith, E. B	1923
Sperry, Elmer A	1917
Sproule, Thomas	1928
Wallis, J. T	1912
Webert, Louis P	1913
Webster, George S	1900
Weinstein, Louis J	1926
Wernicke, O. H. L	1925
Young, Hayes W	1924

A number of these men had been active in various lines of the Society's work. Two of them had held office, Dr. Richard Moldenke having been Vice-President in 1913–1915, and George S. Webster having been President in 1920–1921.

A vigorous effort to increase the society membership has been inaugurated during the year through the efforts of the Committee (of the Executive Committee) on Membership under the chairmanship of H. N. Van Deusen. The aid of the standing committees has been sought in this work through the formation of a general Membership Committee, upon which each standing committee has been asked to appoint a representative who will organize increase of membership work in his standing committee. Because of their close contacts with the industries of the country through their research and standardization activities, the members of standing committees are in a peculiarly effective position to bring the advantages of A.S.T.M. membership to the attention of individuals and companies who will benefit by affiliating with the Society. The Executive Committee earnestly hopes to have the active support of the standing committees in this work during the coming year.

Another activity initiated by Mr. Van Deusen's committee is the endeavor to increase Society membership among individuals of the staffs of companies that hold membership in the Society. There are many such individuals, some frequently representing their companies in committee work, who are not A.S.T.M. members and who thereby miss the advantages of keeping directly in touch with the work of the Society. Plans for membership extension in this direction have received gratifying support in a number of companies.

Membership extension work is also a function of the district committees, of which eight have now been organized, as noted later in the report.

The support of the entire membership is needed in maintaining a steady growth in Society membership. The importance of such growth has been stressed on previous occasions and recently in a special folder prepared by the Membership Committee and mailed to each member of the Society. Not only is a steady expansion of membership needed if the Society's work is to go forward and be extended into new fields, but it is a readily demonstrable fact that the potential value of the Society to each member, as for example in more extensive committee work and in increased publications, increases with the membership. Therefore the Executive Committee asks the interest and support of the members and committees of the Society in vigorous membership extension work during the coming year.

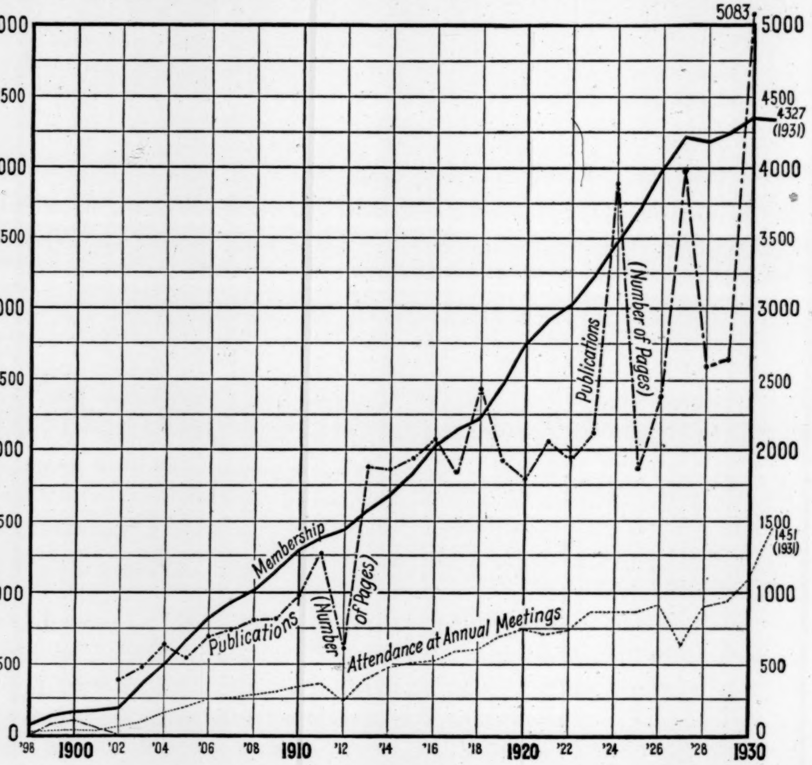

FIG. 1.—Membership and Publications Chart.

Sustaining Membership Proposed.—Studies of membership questions by the Executive Committee have indicated the desirability of providing for a class of Sustaining Members at annual dues of $100. A sustaining membership will afford a means for members, especially companies, firms and corporations, who so desire, to increase their financial support of Society work to a degree more nearly commensurate with the intrinsic value of that work to them. To many company members of the Society the present dues of $30 a year comprise, it is true, the least of their contributions to the Society's work, if they are taking a part in the work of some committee of the Society or are supporting more than one membership. It is believed, however, that there are many companies who would be willing to "sustain" Society activities in the way proposed if the opportunity were afforded and therefore the Executive Committee recommends the adoption by the Society of amendments of the By-laws creating this class of membership. These amendments are offered in a later section of this report.

The Executive Committee has voted, subject to approval of the above recommendation, that sustaining members shall receive all publications of the Society, both regular and special, including reprints, without charge, and an extra set of the standards of the Society if desired.

Local Activities; District Organizations:

Two years ago it was decided to undertake promotional work for extension of Society membership in the principal industrial centers, by the establishment of district committees of members in those centers. Two such committees were organized in 1929 primarily for this purpose, namely in the Chicago District and in the Detroit District. In the same year three district committees were organized on the Pacific Coast, centering in Los Angeles, San Francisco and Seattle, for the broader purpose of promoting closer contacts between our Pacific Coast members and the activities of the Society, but including membership extension work in their functions. It has become evident that such committees may serve very effectively to promote the various interests of the Society, as was demonstrated in 1930 by the holding of the first Regional Meeting under the auspices of the Detroit District Committee. The holding of strictly local meetings of members and guests in the industrial centers for the purpose of stimulating interest in methods of test and properties of materials can also be made an effective means of bringing the Society's work closer to its own members in these districts, many of whom perhaps are unable to attend the annual meetings, and at the same time serves to inform others of the Society's activities and to demonstrate the value of membership in the A.S.T.M.

Since the last annual meeting three new district committees have been organized; one in Pittsburgh in the fall of 1930, under the chairmanship of T. D. Lynch; one in New York, March, 1931, under the chairmanship of F. M. Farmer; and one in Cleveland in May, 1931, under the chairmanship of H. A. Schwartz.

Thus there are a total of eight district committees, in each of which will be considered during the year various means of extending interest in the Society's work in the respective districts.

The Chicago District Committee after serving actively in membership extension work under the chairmanship of John Brunner has been reorganized under the chairmanship of H. G. Farmer.

The work of the three Pacific Coast committees presents several special problems for consideration, principal among which is the closer contact with and more active support of our standing committee work by members and industries in the far West. The elements of time and distance are still handicaps in active participation of Pacific Coast members in committee work, and the formation of special committees in the several districts to study tests and specifications for materials, with their activities coordinated to those of corresponding standing committees by direct representation thereon, is being studied as a practicable step in the direction of closer affiliation with the standardization work of the Society.

Meetings:

On March 18, 1931, there was held in Pittsburgh the second Regional Meeting of the Society, under the auspices of the Pittsburgh District Committee. Sessions in the morning and afternoon were devoted to a Symposium on Welding attended by over 500 members and guests. In the evening there was an informal dinner with over 400 present. The Welding Symposium was arranged with the cooperation of the Pittsburgh section of the American Welding Society and comprised eleven papers, most of which were assembled in preprint form. The complete symposium with discussion will be published this summer. Over 200 visitors were present at the meeting on invitation of the District Committee.

The annual spring group meetings of committees, held in Pittsburgh in conjunction with the Regional Meeting, were highly successful and again demonstrated the advantage of combining the regional and committee meetings where practicable.

From the comments that have been made by members who have attended them, it is believed that these regional meetings will develop into a feature of Society activities of great significance. In its report a year ago the Executive Committee suggested that such regional meetings, if devoted to some technical subject within the Society's field of work and having special local significance, can be developed into a very effective means of bringing A.S.T.M. research and standardization work vigorously and directly to the attention of the industries of the country, at the same time developing greater personal interest in Society affairs on the part of the members themselves. It is hoped, therefore, that the example of the Detroit and Pittsburgh committees will be followed by other district committees in sponsoring such regional meetings.

It is also possible to use more strictly local meetings to serve the same ends. This was demonstrated by the New York District Committee, which sponsored a meeting of members of the New York Metropolitan District in New York on March 5. An informal dinner was attended by 125 members, following which upwards of 300 members and guests listened to three interesting talks on the general subject of limitations of the present knowledge of materials for engineering applications. This committee believes that several meetings on important topics within the Society's scope can be successfully held each year in the metropolitan district and is planning accordingly for the coming year.

A second local meeting was held during the year under the auspices of the Detroit District Committee, who joined with the Detroit chapter of the American Society for Steel Treating in a dinner and meeting on May 11.

A.S.T.M. Committee Activities:

The work of the committees of the Society during the year may be judged by the reports that they will present at this annual meeting. The reports of Committees E-9 on Correlation of Research and E-10 on Standards, together with reviews sponsored by these two committees and published in the A.S.T.M. Bulletin, set forth, respectively, the research and standardization activities of the committees and the Society's accomplishments in these two fields. Therefore, the report of the Executive Committee on committee activities does not refer to these in detail.

Committee E-10 on Standards, organized after the annual meeting in 1929 as an administrative committee for the broad purpose of promoting the standardization work of the Society, is filling a most useful function in passing upon proposed new tentative standards that are offered to the Executive Committee between annual meetings, as well as studying a variety of questions affecting the Society's standardization work and reviewing annually the progress in that work.

At the annual meeting a year ago the formal organization of

Committee B-6 on Die-Cast Metals and Alloys was completed and the committee is actively carrying forward the projects assigned to it as a part of the general plans for reorganizing the Society's committee work in the field of non-ferrous metals and alloys.

The organization of a new standing Committee on Mortars for Unit Masonry, authorization for which was announced in the report a year ago, will be effected during the coming annual meeting. R. E. Davis, Professor of Civil Engineering, University of California, Berkeley, Calif., has been designated as temporary chairman for purposes of organization.

Two new standing committees were authorized during the year. A Committee on Water Analysis is in course of organization under the temporary chairmanship of Max Hecht, Chief Chemist, Duquesne Light Co., Pittsburgh, Pa. The formation of this committee has come about through the need that has developed for methods of analysis of water for industrial purposes in the activities of the Joint Research Committee on Boiler Feedwater Studies, which is organized under the auspices of the American Water Works Association, American Society of Mechanical Engineers and American Public Health Association, and upon which our Society is represented by Messrs. Max Hecht and F. N. Speller. The work will not conflict with but instead will supplement that of the above-mentioned joint committee, whose support of this proposed standardization work has been assured.

The Executive Committee has also authorized the formation of a new standing Committee on Paper. This action has been taken upon the recommendation of Committee E-10, which has felt that the lack of any standards for methods of test and specifications for paper in our publications (except for methods of testing electrical insulating paper) constitutes a serious omission that should be rectified by the preparation of A.S.T.M. standards. Before this decision was reached the matter was discussed with the Technical Association of the Pulp and Paper Industry, which has prepared methods of testing paper on behalf of that industry, and the Society has been assured of the cooperation of the industry in this proposed activity. The title and scope of the proposed committee are still under consideration.

At the request of Committee C-4, its title has been changed to read "Committee C-4 on Clay and Concrete Pipe."

The Executive Committee received two interim reports from standing committees during the year, one from Committee A-1 on Steel and one from Committee C-10 on Hollow Masonry Building Units. Each of these reports advised the Society that the committees had approved revisions in certain specifications upon which they would request action by the Society at the annual meeting this year. These reports were printed and distributed in January.

The Executive Committee has approved the plan of rotation of members-at-large of Committees E-1 on Methods of Testing and E-8 on Nomenclature and Definitions, suggested by these two committees. Beginning with the close of the coming annual meeting the number of members-at-large of Committee E-1 will be increased from seven to nine, the members to serve for three years, the terms of three members expiring each year; and the number of members-at-large of Committee E-8 will be reduced from seven to six, each member serving for a term of three years, the terms of two members expiring each year.

Following the annual meeting in 1930 the Executive Committee requested the officers of each standing committee of the Society to submit a program of their activities for the coming year. The information thus obtained provided an excellent survey of the committee work planned for the year, and was abstracted for publication in the A.S.T.M. Bulletin. The Executive Committee will continue this practice not only for the valuable information that it gives on the committee work of the Society, but also because it will help to systematize the important function of planning committee activities in advance and to stimulate committees that may not be functioning in their respective fields as actively as they should be.

The activities of some of the standing committees, especially of the larger committees, are beginning to assume such proportions that the secretarial and general administrative work involved may, in some cases, no longer be possible on the voluntary basis that has so far prevailed. During recent years there have been occasional suggestions that some committees in order properly to carry out their duties need a paid technical assistant. This year a specific proposal in this direction was made by Committee C-1 on Cement, which led the Executive Committee to adopt the following statement of policy:

> The Executive Committee will consider proposals to place on the staff of the Society men to be assigned to assist in the activities of standing committees, provided the expense involved will be completely financed by the standing committees, such staff members to be subject to direction by the Executive Committee.

Acting upon this statement of policy the Executive Committee has authorized the appointment of a technical assistant to the Society's staff, to be assigned to Committee C-1, provided funds for his salary and expenses are raised by that committee. The location of the headquarters of this assistant is subject to approval of Committee C-1 and the Executive Committee.

Standards Relating to Patents, Copyrights and Trade Marks:

It has been a requirement of the By-laws for many years that any standard or tentative standard in which it is proposed to use or refer to any device or process that forms the subject matter of an existing patent, shall first be submitted to the Executive Committee and shall be submitted to the Society only with the approval of the Executive Committee. Under this provision the Executive Committee adopted certain rulings defining broadly the policy that it would follow in considering (1) the specifying of patented apparatus in A.S.T.M. standards and (2) the development of specifications covering patented materials or patented processes.[1]

With respect to the specifying of patented apparatus, where the patented instrument, appliance or machine is the only one specified in the standard, the Executive Committee has required that the owner of the patent execute a satisfactory agreement with the Society to license any manufacturer approved by the Executive Committee to manufacture such instruments. Two such agreements have so far been written in accordance with this ruling. During the past year several instances were brought to the attention of the Executive Committee where the execution of a license agreement seemed undesirable, which led to the conclusion that the interests of the members of the Society and the users of standards involving a patented apparatus would be adequately protected if assurance satisfactory to the Society were given that if the standard method of the Society were based upon the use of a patented apparatus it would not result in an exorbitant price being placed on the instrument by virtue of the patent monopoly enjoyed. Moreover, experience in the carrying out of these policies has indicated that the conditions will vary quite widely in different instances and that different methods of handling them, entirely fair to the manufacturer of the apparatus and to the Society, should be possible.

The Executive Committee has accordingly modified the rulings applying to the specifying of patented apparatus in A.S.T.M. standards to read as follows:

> Where a standing committee desires to include in a standard of the Society the use of a patented instrument, appliance or machine for testing, for which the committee has written or plans to write such specifications as may be necessary, and where this instrument, appliance or machine is the only one specified

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[1] These rulings have been published in connection with Section 16 of the Regulations Governing Standing Committees since 1927 and appear on page 271 of the 1930 Year Book.

in the standard, the Executive Committee will pass upon such proposal upon its individual merits. The owner and manufacturer thereof must give assurance satisfactory to the A.S.T.M. that a patent monopoly will not result in an exorbitant price to the consuming public. The A.S.T.M. does not undertake to insure anyone utilizing such apparatus, appliance or machine for testing, against liability of infringement or assume any such liability.

Where the patented instrument, appliance or machine concerned is one of two or more alternative instruments, at least one of which is not patented, the Executive Committee will permit reference to such patented instrument in the belief that the interests of the user of the standard are fully protected against an undesirable patent monopoly in that he can use at least one unpatented instrument in accordance with the provisions of the standard.

Under this ruling the Executive Committee has recently granted permission to Committee D-13 on Textile Materials to include reference to certain patented devices in its Standard Specifications for Textile Testing Machines (D 76 – 27), upon assurance of the owner of the patent, satisfactory to the Executive Committee, that the patent monopoly will not result in an exorbitant price of this device to the consuming public.

No change has been made in the ruling applying to standards involving patented materials or patented processes; the Executive Committee will continue to consider upon their respective merits any proposals from standing committees on this subject. In the several cases that have so far come before it the Executive Committee has sought and obtained assurance, first, that the adoption of the standard by the Society confers a definite benefit to the consumer in defining qualities and tests to which the patented material must conform and, secondly, that the conditions under which the patented material is marketed are equitable and generally satisfactory to industry.

As a matter of record, the following specifications have been approved for submission to the Society under this ruling:

Standard Specifications for Aluminum Bronze Castings (B 59 – 28);
Tentative Specifications for Aluminum-Base Alloy Castings (B 26 – 30 T);
Tentative Specifications for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T); and
Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet (B 78 – 30 T).[1]

In this connection the following note is printed with each of the specifications:

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[1] Consideration of the patent phases of these specifications was completed by the Executive Committee April, 1931, and the note is to be added to the specifications at the next printing.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

In the report of Committee B-6 on Die-Cast Metals and Alloys for this year, two specifications are offered, one for Zinc-Base Alloy Die Castings and the other for Aluminum-Base Alloy Die Castings. The former specification involves one alloy covered by an existing patent and the latter involves several alloys that are covered by patents. The Executive Committee has authorized the submission of the first-named specification to the Society; action with respect to the second specification is awaiting review of information recently submitted by Committee B-6.

A question arose during the year regarding the use of copyrighted material in a standard of the Society. The conditions under which it would have been necessary to refer to this copyrighted material would have been detrimental to the use of the standard, particularly its reprinting, and the Executive Committee accordingly declined to permit the inclusion of this material in the standard. Arrangements satisfactory to the committee were made for presentation of the material to the Society as an appendix to the committee report independent of the standard in question. Consideration of this matter and of the related one of use of and reference to trade-marked articles leads the Executive Committee to recommend that Article VI, Section 2, of the By-laws (which also forms Section 16 of the Regulations Governing Standing Committees) be amended to provide that questions affecting the proposed use in a standard or tentative standard of any device or process forming the subject matter of an existing copyright or trade mark be also submitted to the Executive Committee for review prior to submission to the Society.

The necessary amendment of this section of the By-laws is formally proposed in the next section of this report.

Proposed Amendments of the By-laws:

For reasons explained previously in this report, the Executive Committee proposes the following amendments of the By-laws and asks that they be referred by the annual meeting to the required letter ballot vote of the membership:

Amend Article I, Section 1, to read as follows by the insertion of the italicized words:

> The Society shall consist of ***Sustaining Members***, Members, Junior Members, Student Members and Honorary Members.

Amend Article I, Section 2, to read as follows by the insertion of the italicized words:

> A *Sustaining Member or a* Member shall be a person, or corporation, a firm, a technical or scientific society, a teaching faculty, or a library, proposed by two members and elected by the Executive Committee.

Amend Article VI, Section 2, to read as follows by the insertion of the italicized words:

> Reports, resolutions and recommendations pertaining to or involving the use, or proposed use, in a standard or tentative standard, of any device or process which forms the subject matter of an existing patent, *copyright or trade mark*, shall first be submitted to the Executive Committee and shall be submitted to the Society only with the approval of the Executive Committee.

Amend Article VII, Section 1, to read as follows by the insertion of the italicized words:

> The fiscal year shall commence on the first day of January. The annual dues, payable in advance, shall be as follows: For *Sustaining Members, $100; for* Members that are companies, firms, corporations, industrial associations or commercial testing laboratories, $30; for all other Members, $15; for Junior Members, $7.50; for Student Members, $1.50. Honorary Members shall not be subject to dues.

Publications:

During 1930, the usual publications were issued, namely, the Proceedings, the 1930 Book of A.S.T.M. Standards (Part I Metals, Part II Non-Metals), the Year Book and the Index to A.S.T.M. Standards and Tentative Standards, comprising the so-called "regular publications" distributed to all members; and the Book of A.S.T.M. Tentative Standards as a special publication furnished to members on order. A comparative statement of the volume of these publications during the past four years follows:

	1927, PAGES	1928, PAGES	1929, PAGES	1930, PAGES
Proceedings	1706	2088	1937	2421
Book of A.S.T.M. Standards	1871	....	....	2214
Supplement to Book of Standards	....	195	293	....
Year Book	398	309	320	332
Index to A.S.T.M. Standards and Tentative Standards	....	95	109	116
	3975	2687	2659	5083
Book of A.S.T.M. Tentative Standards	824	932	901	864
	4799	3619	3560	5947

The volume of regular Society publications since 1902 is recorded graphically in Fig. 1.

The Proceedings for 1930 were the largest ever published by the Society. A large proportion of the reports and papers making up the Proceedings were preprinted for the annual meeting.

Eight thousand copies of each part of the 1930 Book of A.S.T.M. Standards have been printed, to meet the needs of distribution to members and of sales until the appearance of the 1933 edition.

The A.S.T.M. Bulletin was issued bimonthly throughout the year. As in past years the income from advertising was more than sufficient to meet the actual cost of printing and distributing the Bulletin, $4648 compared to $4476. Advertising in the Index to Standards and Tentative Standards for 1930 provided an income of $1030 towards the total cost of printing and distributing 9000 copies of the Index, about $1550.

In the fall of 1930 an edition of 1000 copies of the Symposium on Developments in Automotive Materials (186 pages) was printed, comprising the papers and discussions at the Detroit Regional Meeting held March 19, 1930, and distributed without charge to members requesting them, a procedure that was made possible through the funds raised by the Detroit District Committee.

A number of important reprints from the 1930 Proceedings have been issued, the principal ones being the List of Alloys, 70 pages, 3000 copies; Tables of Properties of Corrosion-Resistant and Heat-Resistant Alloys, comprising eleven folded insert tables of data, 4500 copies; Symposium on Aircraft Materials, 192 pages, 1000 copies; Symposium on Rosin, 60 pages, 500 copies; Committee D-2 Pamphlet on Petroleum Products and Lubricants, 284 pages, 2000 copies; Committee D-13 Pamphlet on Textile Materials, 122 pages, 1500 copies; Committee D-9 Pamphlet on Electrical Insulating Materials, 192 pages, 600 copies; reprint of Report of Committee A-5 on Corrosion of Iron and Steel, 26 pages, 1000 copies. There was also published the second number of the Fatigue of Metals Abstracts covering articles on the subject in the literature from July 1, 1929, to June 30, 1930, prepared by the Research Committee on Fatigue of Metals.

In March, 1931, eight of the eleven papers comprising the Symposium on Welding for the Pittsburgh Regional Meeting were preprinted, the edition being 1750 copies, and distributed without charge to all members requesting copies and to visitors attending the Symposium. The papers and discussions of the Symposium will be published in cloth binding this summer and sold to members at special prices.

As reported a year ago, 3000 copies of a new publication entitled "Selected A.S.T.M. Standards for Students" were published to provide a group of selected A.S.T.M. specifications and methods of test for student use. This publication has been well received in many of the technical and engineering schools. The present edition will probably meet the needs for the fall term and it is planned to print a new edition for use next year.

The Committee on Papers and Publications is considering the publication of a similar selection of A.S.T.M. standards of special interest to students in chemistry, chemical engineering and metallurgy.

Finances of the Society:

Report for Fiscal Year 1930.—The annual statement of the finances of the Society follows in the report of the auditors for the fiscal year, January 1, 1930, to December 31, 1930, which includes the balance sheet, statement of receipts and disbursements, statement of miscellaneous funds held for committees, the Dudley Medal and Marburg Lecture Fund, and investments.

As will be seen from the balance sheet, the surplus at the close of the fiscal year was $42,532.40. In addition the life membership fund comprised $3005.30; the A.S.T.M. Research Fund amounted to $8387.85; the Headquarters Fund, created to meet the expenses incident to possible removal of the Society's headquarters, totaled $5030; and the Publications Fund, to meet cost of special or extraordinary publications, comprised $4015; making a total of Special Funds of $20,438.05. A comparison of the financial condition of the Society at the close of the past five fiscal years is given in detail at the end of the auditor's report.

The report also lists the funds held for the account of committees and joint committees of the Society (totaling $27,758.90), and gives also a statement of the Dudley Medal and Marburg Lecture Fund, which shows a balance of $7850.58. Investments of Society and other funds are listed.

One feature of the financial operations for the year deserves special mention. It had originally been planned to add one-half of the entrance fees, approximately $1800, to the principal of the A.S.T.M. Research Fund, but the expense of publishing the Proceedings was considerably over the amount estimated and it was decided that just at this time it was more important to conserve publication funds than to increase the Research Fund and the money was therefore applied to publications. The budget operations for the year showed a favorable balance of about $1300, which it was decided to apply to 1931 operations as indicated below.

In the foregoing financial statement no account has been taken of the assets of the Society in the form of publications in stock. The inventory on June 1, 1931, may be summarized approximately as follows:

		NUMBER OF COPIES
Proceedings		5 800
Index to Proceedings	Vols. I–XII, incl.	500
	Vols. XIII–XX, incl.	670
	Vols. 21–25, incl.	650
Book of A.S.T.M. Standards	Part I, Metals	3 050
	Part II, Non-Metals	3 100
Book of A.S.T.M. Tentative Standards		150
Reprints of 427 Standards	(approximate)	25 000
Special reprints for general sale	(approximate)	6 500

REPORT OF THE AUDITORS FOR THE FISCAL YEAR, JANUARY 1, 1930, TO DECEMBER 31, 1930

PHILADELPHIA, January 8, 1931.

AMERICAN SOCIETY FOR TESTING MATERIALS,
Mr. C. L. Warwick, *Secretary-Treasurer,*
Philadelphia, Pa.

Gentlemen:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the seven months ended December 31, 1930, having previously made a similar audit and report for the preceding five months ended May 31, 1930, and at both audits found the accounts to be correct and to be in excellent condition.

We submit herewith balance sheet as of December 31, 1930, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the seven months ended December 31, 1930, as also for the five months ended May 31, 1930, as reported in ours of June 13, 1930, and found the same to be correct.

We have verified by actual inspection and count the securities as scheduled under Investments and report all interest collected to December 31, 1930, and all subsequent coupons attached. Respectfully submitted,

(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1930

ASSETS

Current Funds		$4 567.78	
Investments		44 255.51	
Accounts Receivable:			
For Publications	$5 589.48		
Advertising	1 915.00		
Members, for 1930 Dues	3 133.40		
Members, for Binding	253.50		
		10 873.38	
Furniture and Fixtures		6 209.36	
			$65 906.03

LIABILITIES

Publications paid for in advance		$923.35		
Advertising paid for in advance		52.00		
Members Dues paid in advance		696.65		
Members Binding paid in advance		14.00		
Entrance Fees paid in advance		120.00		
			$1 806.00	
New Internat. Assn. for Testing Materials			4.00	
Franklin Memorial Museum Fund			273.26	
Income, A.S.T.M. Research Fund			852.32	
Life Membership Fund	$3 005.20			
A.S.T.M. Research Fund	8 387.85			
Headquarters Fund	5 030.00			
Publications Fund	4 015.00			
		$20 438.05		
Surplus		42 532.40		
			62 970.45	
				$65 906.03

RECEIPTS AND DISBURSEMENTS

JANUARY 1, 1930, TO DECEMBER 31, 1930

Current Funds, January 1, 1930			3 683.76

RECEIPTS

Current Dues	$80 790.13		
Past Dues	921.02		
Advance Dues	670.08		
Income, Life Membership Fund	150.00		
Entrance Fees	3 575.00		
Total Dues		$86 106.23	
Separate Standards	$4 754.86		
Book of Standards	6 512.11		
Book of Standards—Members for both Parts	4 916.00		
Book of Tentative Standards	6 880.20		
Proceedings.	3 512.97		
Selected Standards for Students	779.87		
Miscellaneous (including special reprints)	7 251.95		
Total Sale of Publications		34 607.96	
Binding (Members)		879.00	
Advertising in Bulletin		4 442.25	
Advertising in Index to Standards and Tentative Standards.		680.00	
Authors' Reprints		331.50	
Sale of Certificates of Membership		40.00	
Interest on Deposits and Investments		4 290.75	
Accrued Interest and Premium		180.98	
Excess Remittances		182.48	
Investments matured or sold		50 414.37	
Carried forward		$182 155.52	$3 683.76

Brought forward	$182 155.52	$3 683.76
Engineers Club (see Disbursements)	212.40	
Income, A.S.T.M. Research Fund	450.00	
Registration and other fees, Annual Meeting	1460.00	
Seaview Golf Club (see Disbursements)	305.65	
New Internat. Assn. for Testing Materials, Dues	309.00	
Regional Meeting	947.82	
Franklin Memorial Museum Subscriptions	620.00	
Total Receipts	$186 460.40	
		$190 144.16

DISBURSEMENTS

Publications:			
Year Book	$3 581.08		
Book of Standards	21 898.46		
Selected Standards for Students	681.47		
Book of Tentative Standards	3 471.72		
Proceedings	30 928.22		
Preprints	4 387.86		
Bulletin and Circulars to Members	6 844.98		
Separate Standards	2 107.77		
Authors' Reprints	489.21		
Index to Standards and Tentative Standards	1 549.89		
Detroit Regional Meeting Papers	1 932.12		
Miscellaneous (including special reprints)	3 243.51		
		$81 116.29	
Salaries		39 480.24	
General Office Expenses		8 709.51	
Expenses, Standing Committees		2 249.82	
Expenses, Annual Meeting		4 507.73	
Traveling Expenses—Administrative Committees		2 272.27	
Rent and Insurance, Storage Rooms		321.00	
Rent, Headquarters		3 000.00	
Headquarters Maintenance		338.65	
Furniture and Fixtures		1 003.05	
Certificates of Membership		23.00	
American Standards Association and Sectional Committees		1 933.07	
Investments		38 500.00	
Income A.S.T.M. Research Fund		73.50	
U. S. National Committee International Electrotechnical Commission		330.00	
Central Lumber Standards Committee		25.00	
Accrued Interest and Premium		180.98	
Refund of Excess Remittances		182.48	
Seaview Golf Club (see Receipts)		305.65	
Engineers Club (see Receipts)		212.40	
New Internat. Assn. for Testing Materials, Dues		309.00	
Franklin Memorial Museum Subscription		100.00	
Franklin Memorial Museum Cost of Circularizing Members		246.74	
Miscellaneous		156.00	
Total Disbursements			185 576.38
Balance, Current Funds, December 31, 1930			$4 567.78

Balance accounted for as follows:		
Cash on hand	$67.78	
Savings Fund	500.00	
Baltimore & Ohio R. R. Bonds 20 year 4½'s due 1933 carried as Current Funds	15 000.00	
		$15 567.78
Less checks drawn but not paid against cost of Proceedings		11 000.00
		$4 567.78

MISCELLANEOUS FUNDS

In addition to the regular Society funds the Secretary-Treasurer has on hand the following funds, accounted for as follows:

Committee A-1 on Steel	$140.54	
Committee A-3 on Cast Iron	1 004.14	
Committee A-5 on Corrosion of Iron and Steel	7 474.86	
Committee A-5, Subcommittee X on Embrittlement Investigation	7 620.00	
Committee B-3 on Corrosion of Non-Ferrous Metals	5 226.09	
Committee C-1 on Cement	870.84	
Committee C-1 Cement Reference Laboratory	1 035.04	
Committee C-9 on Concrete and Concrete Aggregates	590.07	
Committee C-10 on Hollow Masonry Building Units	232.19	
Committee D-1 on Preservative Coatings	30.47	
Committee D-14 on Screen Wire Cloth	62.55	
Committee D-18 on Natural Building Stones	191.12	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	94.32	
A.S.A. Sectional Commmittee on Cast-Iron Pipe	1 197.67	
A.S.A. Sectional Committee on Classification of Coals	1 989.00	
Total Committee Funds		$27 758.90

DUDLEY MEDAL AND MARBURG LECTURE FUND

Balance, January 1, 1930:		
Investments	$6 977.50	
Cash on hand	735.55	
		7 715.05
RECEIPTS		
Interest on Deposits and Investments	$422.78	
		$8 137.83
DISBURSEMENTS		
Cost of 1930 Medals	$84.00	
Honorarium, 1930 Lecturer	200.00	
Engrossing 1930 Lecture Certificate	3.25	
		287.25
Balance December 31, 1930:		
Investments	$6 977.50	
Cash on hand	873.08	
		$7 850.58

INVESTMENTS

SOCIETY FUNDS

General:			
$2 000	Michigan Central Equipment Bonds, 6's due 1932	$2 085.96	
1 000	Baltimore & Ohio R. R. Refunding & General Bonds, 6's due 1995	1 082.00	
4 500	Baltimore & Ohio R. R. 20 year Convertible Bonds, 4½'s due 1933	4 606.55	
16 000	Baltimore & Ohio R. R. Refunding & General Bonds, 5's due 1995	16 200.00	
2 000	Penna. R. R. Bonds Seconds, 5's due 1964	2 000.00	
3 000	Am. Tel. & Tel. Co. S. F. Deb. Bonds, 5's due 1960	3 159.75	
500	Consolidated Gas Co. of N. Y. Bonds, 20 year 5½'s due 1945	531.00	
6 000	Southeastern Power & Light Co. 6% Gold Deb. Bonds, Series A, due 2025	6 240.00	
$35 000			$35 905.26
A.S.T.M. Research Fund:			
$3 000	Baltimore & Ohio R. R. Refunding & General Bonds, 6's due 1995	$3 246.00	
1 500	Baltimore & Ohio R. R. 20 year Convertible Bonds, 4½'s due 1933	1 511.25	
1 500	Consolidated Gas Co. of N. Y. Bonds, 20 year 5½'s due 1945	1 593.00	
2 000	1st Mortgage Real Estate 6% Bonds on 1315–17 Spruce St	2 000.00	
$8 000			8 350.25
$43 000			$44 255.51

DUDLEY MEDAL AND MARBURG LECTURE FUND

$6 500	Baltimore & Ohio R. R. Refunding and General Bonds, 6's due 1995		6 977.50

COMMITTEE FUNDS

$7 000	U. S. Liberty Bonds, 4th 4¼'s due 1938:		
	Committee A-5	$6 629.45	
	Committee C-1	509.53	
			7 138.98
$56 500			$58 371.99

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1926–1930, INCLUSIVE.

Fiscal Year	Assets				Liabilities			
	Current Funds	Investments	Accounts Receivable	Furniture and Fixtures	Accounts Payable	Reserve for Book of Standards and Index to Proceedings	Special Funds	Surplus
1926.......	$6 810.58	$33 196.26	$4 905.90	$3 753.09	$1 249.01	$11 121.16	$1 805.20[b]	$34 490.46
1927.......	1 594.65	28 403.10	7 461.93	5 023.49	1 919.49	....	5 051.20	35 512.48
1928.......	978.56	44 752.09	6 831.10	5 327.09	972.04	6 057.80[a]	10 354.30	40 504.70
1929.......	3 683.76	54 707.09	6 226.93	5 896.31	1 913.27	12 012.80[a]	19 438.05	37 149.97
1930.......	4 567.78	44 255.51	10 873.38	6 209.36	2 935.58	....	20 438.05	42 532.40

[a] Book of Standards Reserve only.
[b] Life Membership Fund only.

1931 Finances.—The Society's activities for the current fiscal year have been based on a budget that anticipates an income, exclusive of investments matured or sold, of $138,700, of which $87,000 is estimated from dues and entrance fees, $35,600 from sales of publications and $16,100 from a number of miscellaneous items including advertising, interest on deposits and investments, registration fees at annual meeting and gross income from the Exhibit of Testing Apparatus and Machines. In addition, $1000 has been appropriated from the Publications Reserve towards the expense of publishing the papers for the Pittsburgh Regional Meeting; and unappropriated surpluses from 1929 and 1930 operations totaling approximately $2700 have been applied to 1931 operations to strengthen the publicity and promotional activities of the Society; making the total estimated receipts for the year $142,400.

The usual provisions have been made for normal disbursements of the Society. The budget for publications is $63,900, which includes $27,000 for the current Proceedings and the setting aside of $6000 towards the expense of publishing the 1933 Book of A.S.T.M. Standards. Two symposiums during the 1931 annual meeting are under joint auspices with other societies, with whom special arrangements are being made to share the expense of publication. The budget provides for all current expenses, including salaries, general office expense, standing committee expenses, annual, regional and local meeting expenses, headquarters maintenance, etc. The organization of district committees and plans for local meetings are expected to require some further appropriations for these activities. The budget also provides for the expenses of the exhibit and for the assignment of one-half of the entrance fees to the A.S.T.M. Research Fund.

Marking on A.S.T.M. Apparatus:

In a number of instances where committees of the Society have developed specifications for testing apparatus, requirements have been included that the apparatus be marked in a manner identifying it with the Society's standard, a typical illustration being the "A.S.T.M. High-Distillation Thermometer." The Scientific Apparatus Makers of America recommended that in such cases it should also be required that the name or trade mark of the manufacturers of such apparatus be marked thereon as a means of identifying the origin of the apparatus and placing the name of the manufacturer back of the statement implied by the appearance of the "A.S.T.M." mark that the apparatus conforms to Society standards. The Executive Committee referred this proposal to Committee E-10 on Standards for consideration; and upon its recommendation the Executive Committee adopted the following resolutions:

> RESOLVED, that where the specifications of the Society require that apparatus be marked in some way with the initials "A.S.T.M." it also be required that the name or trade mark of the manufacturer be marked on the apparatus, with the understanding that this requirement need not apply where apparatus specified by the Society is not required to be marked as "A.S.T.M." apparatus; further
>
> RESOLVED, that the attention of standing committees be called to the desirability, where requirements for apparatus are specified, of specifying that such apparatus be marked to identify it as A.S.T.M. apparatus, including the manufacturer's name or trade mark.

Committee E-10 on Standards is giving some consideration to a proposal that a certificate be furnished by apparatus manufacturers to accompany apparatus made in accordance with A.S.T.M. requirements, in which the manufacturer certifies to the conformity with A.S.T.M. requirements. The committee has advised the Executive Committee that it approves the certificate conformity plan in principle and the Executive Committee has suggested that the proposal be discussed with manufacturers of testing apparatus and testing equipment.

Publicity and Promotion of Society Activities:

The growth of technical activities and administrative work within the Society has placed such added responsibilities on the present staff as to make it increasingly difficult to give the attention to promotional and publicity work that it deserves in the interest of proper advancement of the purposes for which the Society is organized. In its report a year ago, the Executive Committee outlined the activities that were desirable in this direction, including the extension of the work of gathering and disseminating through various channels, information about the work that is being done throughout the Society, particularly in the standing and research committees. The publication of the A.S.T.M. Bulletin and its expansion along desirable lines is a problem closely related to this field of promotional activities and to which it has not been possible in the past year or two to devote adequate attention. Promotional activities wisely and judiciously carried on will bring about greater use of the Society's standards and with it an increased sale of its publications, which is, next to membership dues, the largest source of the Society's income.

The Executive Committee accordingly has added another technically trained man to the staff, with the necessary additional stenographic help, gradually to take over details of this type of work. For the first year it is applying towards the expense thus incurred unappropriated surpluses from 1929 and 1930 operations, totaling approximately $2700, meeting the balance of the expense from current income.

The following summary of principal channels for publicity of Society work now being developed will give some idea of the scope and possibilities of such work: Reviews of publications; publicity given to annual, regional and local meetings and committee meetings; use of A.S.T.M. Bulletin; news releases to technical journals, principally in respect to committee activities; circularization of tentative standards for review and comment; submission of standards to American Standards Association for approval as American Standard; wide distribution of the Index to A.S.T.M. Standards and Tentative Standards; distribution of standards to administrators of building codes; preparation of special articles; various direct contacts with industry, such as with trade associations; and the widespread contacts established by standing committee activities. The work done along these lines during the past year has served to indicate the possibilities of each of these several means of approach and to justify more extensive work than has heretofore been possible.

The Society offered to supply a talk on engineering materials as one of a series of radio talks on "Romance of American Industry." As a result Past-President H. F. Moore spoke on "The Romance of Engineering Materials," November 1, 1930, over a nationwide broadcasting chain. Aside from the direct publicity thus afforded considerable use was made of this talk by the technical journals.

For the past two years the Society has accepted the invitation of the American Foundrymen's Association to maintain a booth in the educational section of the Foundry Exposition, in which to show those activities of the Society of special interest to the foundry industry.

Exhibit of Testing Apparatus and Machines:

At various times in recent years it has been suggested that an exhibit of testing apparatus and machines could be developed into a valuable technical and educational feature of the annual meetings of the Society, providing opportunity to acquire first-hand knowledge of available testing apparatus and especially of newer devices and developments, and lending valuable emphasis to the increasing importance of the Society's work in developing methods of testing and of requirements for testing apparatus. The Executive Committee last fall made a careful study of the proposal, consulting with many of the active members of the Society, including the officers of the standing committees, and with a representative group of manufacturers and distributors of testing equipment. This study led to the conclusion that such an exhibit could be made of outstanding significance and value both to the Society and to exhibitors, by bringing to the science of testing materials the latest developments and advances in technique and use of testing equipment. It was therefore decided to offer the facilities of the coming annual meeting for holding an exhibit of testing apparatus and machines—the first such exhibit ever to be sponsored by the Society.

Announcements of the exhibit in the March and April issues of the A.S.T.M. Bulletin have been full and complete. Emphasis has been placed upon the development of a scientific and educational atmosphere in the exhibit consistent with the technical nature of the Society's activities. The cooperation of exhibitors has been sought to stress the technical features of design, construction and use of apparatus and machines, adaptation to standard as well as to special tests of materials, relationship to A.S.T.M. requirements, development of new and unusual apparatus such as will be of particular interest to committees of the Society. The exhibit has been limited to apparatus, equipment and machines used in the testing of materials, including recording and control equipment if used in testing.

The Exhibit has met with gratifying response from manufacturers and distributors of testing equipment; and notwithstanding that present industrial conditions are in some respects not altogether propitious for the initiation of an exhibit of this kind, a representative number of firms are participating and a wide and quite representative list of testing equipment will be displayed.

In order that some of the equipment designed in government, research and university laboratories and being developed by committees of the Society, not available commercially, might be shown, such laboratories as well as the standing committees were invited to exhibit such apparatus. Although the time has been somewhat short, there will be a number of these non-commercial exhibits, which will include some distinctly interesting developments in the testing of materials.

The development and management of the exhibit was delegated by the Executive Committee to the Secretary and an Advisory Committee on Exhibits consisting of Messrs. H. N. Van Deusen, chairman, Cloyd M. Chapman and H. E. Smith.

Edgar Marburg Lecture for 1931:

Upon recommendation of the Edgar Marburg Lecture Committee, consisting of T. D. Lynch, chairman, H. C. Mougey and F. E. Richart, the Executive Committee has invited Dr. A. Nadai, Research Engineer of the Westinghouse Electric and Manufacturing Co., to deliver the sixth Edgar Marburg Lecture at this annual meeting. Doctor Nadai will speak on "The Phenomenon of Slip in Plastic Materials."

Award of the Charles B. Dudley Medal for 1931:

Upon the unanimous recommendation of the Committee on Medal Award, consisting of J. H. Gibboney, chairman, F. H. Jackson and H. W. Gillett, the Executive Committee has awarded the Charles B. Dudley Medal to A. H. Pfund, Professor of Physics, Johns Hopkins University, for his paper on "Hiding Power Measurements in Theory and Application" presented at the annual meeting of the Society a year ago.

American Standards Association:

Since the detail of administrative work in connection with the Society's participation in the activities of the American Standards Association is now in the hands of Committee E-10 on Standards, to whose report reference should be made, the present report is confined to certain administrative matters affecting the Society's relationship with the Standards Association.

There are now before the Executive Committee proposed amendments to the Constitution of the American Standards Association, which have been approved by its Board of Directors and by the Standards Council. These amendments provide, briefly, for an enlargement of the Board of Directors from nine to fifteen elected directors; authorization for appointment of an Executive Committee of the Board; provision for a chairman and vice-chairman of the Standards Council; and modification of the procedure to amend the Constitution to make it mandatory for formal opportunity to be provided to the Standards Council to make recommendations in regard to proposed changes, final authority as at present remaining in the hands of the member bodies. A study of the amendments has indicated their desirability at this time and the Society's representatives on the Standards Council have recommended approval. Action is to be taken by the Executive Committee at its next meeting.

As originally proposed, these amendments included a revision of the provision in the A.S.A. Constitution stating that it is not a function of the Standards Association "to formulate standards." This proposed revision was opposed by several of the member bodies, including this Society, and was later withdrawn.

The Society has carried forward as actively as possible the standardization projects under A.S.A. procedure for which it is sponsor or joint sponsor; and has carried on as rapidly as conditions and facilities permitted the submission of A.S.T.M. standards for approval as American Standard under the "proprietary sponsorship plan." Details of this work are being reported by Committee E-10.

The Executive Committee took formal action during the year to approve the report of the Society's representatives on the Sectional Committee on Insulated Wire and Cables recommending the adoption of the report of the sectional committee which included recommendations that Specifications for Weatherproof Wires and Cables, Heat-Resisting Wires and Cables and Specifications for Code Rubber Insulation for Wire and Cable for General Purposes be approved as Tentative American Standard.

Studies of a general nature that are being made under the auspices of the American Standards Association that are of direct interest to the Society include the work of the special committee on Form and Arrangement of Standards and a study by a committee of the A.S.A. Board of Directors of the plans for certification of commodities in accordance with recognized specifications.

Mr. J. A. Capp has been reappointed as one of the Society's representatives on the Standards Council for a term of three years.

On invitation by the Standards Association, the Society nominated Mr. Quincy Bent, Vice-President of the Bethlehem Steel Co., for re-election as a member of the A.S.A. Board of Directors. Mr. Bent was subsequently elected and will serve on the Board for a term of three years.

International Relations:

International Standardization Activities.—A year ago the Executive Committee reported to the Society the consummation of formal membership of the American Standards Association in the International Federation of National Standardizing Associations (I.S.A.), and referred among other things to the importance of establishing a procedure in the A.S.A. for handling international projects on tests and specifications for materials for which the A.S.T.M. is sponsor body. A general agreement on such procedure has since been reached, defining the relationships between the I.S.A., the A.S.A. and sponsor bodies, which agreement will be considered for incorporation in the general Rules of Procedure of the A.S.A.

One standardization project for which the Society is sponsor under A.S.A. procedure has reached the status of an international project, namely, methods of testing and nomenclature of petroleum products. The I.S.A. invited the American Standards Association to assume the secretariat for the development of this project internationally and the A.S.A. in turn invited this Society as American sponsor for the project to undertake the work, and this invitation has been accepted. The sectional committee on the subject, the personnel of which is coincident with the Society's D-2 on Petroleum Products and Lubricants, is now developing with the officers of the Society and of the A.S.A. the details of procedure that should be followed in international consideration of the subject.

New International Association for Testing Materials.—Plans for the International Congress on Materials in Zurich, September 6 to 12, under the auspices of the New International Association for Testing Materials, have been completed and were announced directly to the American members of the N.I.A.T.M., and to all members of the Society through the A.S.T.M. Bulletin. Through the efforts of Past-President W. H. Fulweiler, American member of the Permanent Committee of the N.I.A.T.M., papers by the following members of the Society have been included in the several sections of the program of the Congress:

Section A, Metals:
- "Advances in Microscopy," by F. F. Lucas
- "Stress Corrosion of Metals," by D. J. McAdam, Jr.

Section B, Non-Metallic Inorganic Materials:
- "Designing Concrete for High Strength, Low Permeability and Low Shrinkage," by W. A. Slater
- "Stresses and Strains in Reinforced-Concrete Columns," by F. E. Richart

Section C, Organic Materials:
- "Sampling Coal," by W. A. Selvig
- "Tests for Bituminous Materials," by Prévost Hubbard and C. S. Reeve

Section D, Questions of General Importance:
"Present Status of Particle Size Measurement," by L. T. Work
"Calibration of Testing Machines," by H. F. Moore
"Ideal and Practical (Test) Relations between Elasticity and Plasticity, Tenacity and Brittleness," by F. B. Seely.

Official Society delegates to the Congress will be appointed by the Executive Committee.

It is understood that a proposal will be made at the International Congress that the dues of individual members of the N.I.A.T.M. be increased from $1 to $2 per year and of company members from $2 to $4 a year. Such proposed increase of dues is in accord with views that have been expressed by the Executive Committee since it has become evident that the present dues are inadequate for financing the expenses of the International Association. Thus it has developed that the cost of publication and distribution of the four volumes of "First Communications," comprising preliminary reports procured by the International Association as study material for the final program of the Congress, has considerably exceeded the financial resources of the N.I.A.T.M., and that the members of the Permanent Committee are expected to arrange in their respective countries for the financing of this deficit. No definite action in this matter has been possible in the absence of specific information which has been requested.

International Association of Road Congresses.—The Society participated in the Sixth Congress of the Permanent International Association of Road Congresses held in Washington last fall, the Executive Committee having appointed Messrs. Prévost Hubbard and P. J. Freeman as official delegates to the Congress. Mr. H. S. Mattimore served as A.S.T.M. member of the Reception Committee of the Congress.

A report on definitions of terms relating to bituminous road materials was submitted to the American member of the Road Congress committee on this subject, on behalf of Committees D-2 on Petroleum Products and Lubricants, D-4 on Road and Paving Materials and D-8 on Bituminous Waterproofing and Roofing Materials.

Franklin Memorial Museum:

In view of the progress that has been made during the past year towards establishing the Benjamin Franklin Memorial Museum, the committee appointed to function in an advisory capacity to that Museum, under the chairmanship of S. T. Wagner, has forwarded to the Museum authorities a report formulated by the Subcommittee on Testing Apparatus and Methods, of which H. F. Moore is chairman, making definite suggestions concerning certain fundamental considerations in the exhibit of testing apparatus. A further report on exhibit of engineering materials is now in preparation. F. B. Foley has been added to the committee in place of C. E. Chase.

The members of the Society contributed the sum of $500 by subscription to this project.

Chicago Museum of Progress:

The Executive Committee has recently appointed the following committee to serve in an advisory capacity to the Chicago Museum of Progress: H. F. Moore, chairman, F. S. Crane, F. R. McMillan, H. H. Morgan and L. W. Spring.

Miscellaneous Cooperative Work:

Much cooperative work with other organizations in addition to that previously recounted in this report is carried on each year on an established and practically routine basis through joint committees, representation of other Societies on A.S.T.M. committees and Society representation upon committees of other organizations. Mention of many of these projects, both in the fields of research and of standardization, will be found in the annual reports of Committees E-9 on Correlation of Research and E-10 on Standards. A few such examples of cooperative work that have engaged the attention of the Executive Committee during the past year are commented upon briefly below:

Arrangements have been concluded with the American Welding Society whereby the A.S.T.M. will engage in specification work in the welding field, leaving research work in that field to the Welding Society. The question of specifications for welding wire is active at the present time and the Welding Society has designated representatives to serve on the subcommittee of Committee A-1 to which this subject has been assigned.

The American Electroplaters' Society has expressed interest in the corrosion test work of Committee A-5 on Corrosion of Iron and Steel and a desire to cooperate with the committee. Arrangements have therefore been made for the two societies to cooperate closely in further studies of electroplated products.

The National Association of Purchasing Agents is interested in purchase specifications and has a number of standing committees organized dealing with specific materials. It follows the work of our Society closely and during the year arrangements have been effected whereby the association has a representative on Technical Committee A on Gasoline and Technical Committee B on Motor Oils of Committee D-2 of the Society.

The Society participated in a conference held under the auspices of the Optical Society of America to discuss the organization of an Inter-Society Committee on Color Specifications. Committees D-1 on Preservative Coatings for Structural Materials, D-2 on Petroleum Products and Lubricants and D-13 on Textile Materials were represented in the conference, which led to the decision to form an Inter-Society Color Council to deal with matters relating to the standardization, description and specification of color. The Executive Committee has accepted an invitation to participate in the work of this Council and has designated M. Rae Paul, representing Committee D-1, as the Society's official representative, with H. M. Hancock, representing Committee D-2, and W. M. Scott, representing Committee D-13, as alternates.

In pursuance of action taken last year, preprints of all the new and revised standards have been forwarded to the Scientific Apparatus Makers of America with the suggestion that criticisms and comments on recommendations affecting testing apparatus be made by the time of the annual meeting if possible.

The Executive Committee has designated J. M. Darke, as representative, with H. M. Williams as alternate, on the Committee on Deep Drawing Steel of the Pressed Metal Institute. F. W. Hinrichs and W. B. Gregory have been designated as representatives of the Society at the meetings of the Association for the Advancement of Science, Professor Hinrichs to attend the meeting at Pasadena in June and Professor Gregory the meeting at New Orleans in December. P. H. Cathcart has been appointed a member of the Advisory Board of the Federal Specifications Board Paint Committee.

The Society accepted an invitation to participate in the National Western Metal Congress held in San Francisco in February, and a successful technical session was sponsored by the three Pacific Coast District Committees, at which three papers by Pacific Coast members were presented and received with interest.

Respectfully submitted on behalf of the Executive Committee,

K. G. MACKENZIE,
President.

C. L. WARWICK,
Secretary-Treasurer.

REPORT OF COMMITTEE A-1
ON
STEEL

During the past year Committee A-1 held two meetings, one on January 16, and the second on March 20, 1931. A third meeting will be held prior to the presentation of this report to the Society at which the report will be reviewed and other matters considered.

The Advisory Committee has held three meetings at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 189, of which 85 are classified as producers, 80 as consumers, and 24 as general interests.

New Tentative Specifications for Structural Steel for Ships (A 131 – 31 T)[1] meeting the requirements of the inspection societies, ship builders, and Government codes were approved by the committee too late for inclusion in the 1930 report. Committee A-1 accordingly referred these specifications to Committee E-10 on Standards for publication as tentative.[2] The specifications were approved by Committee E-10 on February 20, 1931. These specifications were prepared by Subcommittee III on Structural Steel for Ships (R. C. Davis, chairman) and will supersede when adopted the present Standard Specifications for Structural Steel for Ships (A 12 – 21) and for Rivet Steel for Ships (A 13 – 24).

Recommendations Affecting Standards and Tentative Standards

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot on each item. They are then referred to, where necessary, in greater detail, being grouped for convenience in the order of the respective subcommittee directly responsible for them.

Proposed New Tentative Standards.—The committee recommends that the following proposed tentative specifications be accepted for publication as tentative as appended hereto:

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[1] See p. 641.—Ed.

[2] In submitting the specifications to Committee E-10 on Standards, the committee reported the results of the letter ballot vote as follows: 118 members returned their ballots, of whom 83 voted affirmatively and none negatively.

Proposed Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives;[1]

Proposed Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding.[2]

Proposed Revisions in Standards.—The committee recommends that revisions in the following standards, which are given in full in the Appendix to this report, be submitted to letter ballot of the Society. These revisions are divided into two groups, as follows:

Group A.—Revision in the following standard which the committee recommends be referred to letter ballot of the Society immediately by the necessary nine-tenths vote of the annual meeting, for adoption as standard:

Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27).

Group B.—Revisions in the following standards recommended for publication as tentative for one year before referring them to letter ballot of the Society for adoption:

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30);

Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14);

Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 27);

Standard Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27);

Standard Specifications for Steel Tie Plates (A 67 – 30);

Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30);

Standard Specifications for Structural Silicon Steel (A 94 – 29).

Proposed Revisions in Tentative Standards.—The committee recommends that the following tentative specifications be revised as given in detail in the Appendix, and the specifications as revised continued as tentative:

Tentative Specifications for Carbon-Steel Forgings for Locomotives (A 20 – 29 T);

Tentative Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 – 29 T).

Advancement to Standard of Tentative Revision of Standard.—The committee recommends that the tentative revision, proposed in 1930, in the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27) be adopted as standard.

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[1] See p. 668.—ED.

[2] See p. 648.—ED.

Tentative Standards Continued as Tentative.—The committee recommends that the following tentative specifications be continued as tentative for another year without revision:

Tentative Specifications for Soft Steel Track Spikes (A 65 – 26 T);
Tentative Specifications for Electric Cast-Steel Stud-Link Anchor Chain (A 77 – 28 T);

TABLE I.—ANALYSIS OF LETTER BALLOT VOTE.

Items	Affirmative	Negative	Not Voting
I. PROPOSED NEW TENTATIVE STANDARDS			
Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives	68	2	41
Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding	74	1	36
II. PROPOSED REVISION OF STANDARDS			
Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27), immediate adoption	71	0	40
Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30)	63	1	47
Specifications for Rail-Steel Concrete Reinforcement Bars (A16 – 14)	69	2	36
Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 19 – 27)	68	1	42
Specifications for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27)	68	1	42
Specifications for Steel Tie Plates (A 67 – 30)	57	0	58
Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30)	74	1	36
Specifications for Structural Silicon Steel (A 94 – 29)	70	1	40
III. PROPOSED REVISIONS IN TENTATIVE STANDARDS			
Specifications for Carbon-Steel Forgings for Locomotives (A 20 – 29 T)	68	1	42
Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 – 29 T)	66	0	45
IV. ADVANCEMENT TO STANDARD OF TENTATIVE REVISION OF STANDARD			
Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27)	72	0	39

Tentative Specifications for Cold-Rolled Strip Steel (A 109 – 27 T);
Tentative Specifications for Marine Boiler Steel Plates (A 114 – 29 T);
Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 28 T);
Tentative Specifications for Austenitic Manganese-Steel Castings (A 128 – 30 T);
Tentative Specifications for Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T);
Tentative Specifications for Structural Steel for Ships (A 131 – 31 T).

The above recommendations have been referred to letter ballot of the committee, which consists of 189 members; 111 ballots have been cast; 78 members having failed to return their ballot. The analysis of the vote of the committee is given in Table I.

SUBCOMMITTEE ACTIVITIES

In the following the committee presents the foregoing recommendations, in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective subcommittees responsible for them:

Subcommittee I on Steel Rails and Accessories (E. F. Kenney, chairman).—The activities of this subcommittee are closely allied with the A.R.E.A.

Subcommittee I has recommended, as given in the Appendix, a tentative revision of the Standard Specifications for Steel Tie Plates (A 67 – 30) in order to bring these specifications into agreement with the A.R.E.A. specifications for tie plates. The subcommittee is considering the withdrawal of the Standard Specifications for High-Carbon-Steel Splice Bars as covering material no longer in use.

Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock (A. W. Carpenter, chairman).—Subcommittee II has prepared new specifications for structural steel of higher tensile properties for use in bridges, buildings and other heavy construction, the specifications covering steel with a tensile strength of 60,000 to 72,000 lb. per sq. in. These specifications will come up for consideration at a meeting of Committee A-1, to be held during the annual meeting, and if approved will be subsequently submitted to Committee E-10 on Standards during the current year for publication as tentative.

This subcommittee is also developing new specifications for structural rivet steel to supersede when adopted the rivet requirements in present standard specifications for structural steel. These new specifications will also be considered by Committee A-1 at the annual meeting, and if approved will be referred to Committee E-10 for publication as tentative.

Revisions are being proposed as tentative in the Standard Specifications for Structural Silicon Steel (A 94 – 29) because of their wider use, and in order to provide for heavier and lighter gages than those originally covered by the specifications.

Subcommittee IV on Spring Steel and Steel Springs (H. W. Faus, chairman).—This subcommittee proposes a revision, as given in the Appendix, in the silicon content requirement of the Tentative Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 – 29 T) and recommends that the specifications be continued as tentative. The subcommittee also has under consideration new specifications for heat-treated carbon-steel elliptical springs.

Subcommittee V on Steel Reinforcement Bars (H. H. Morgan, chairman).—This subcommittee is recommending a tentative revision, as given in the Appendix, of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30) embodying methods of branding and tagging, determining areas, limits on weight variations, and a revision of the so-called machining clause. A tentative revision is also being recommended in the Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14) which includes similar changes in the methods of determining area, limits on weight variations and a revision of the so-called machining clause.

Subcommittee VI on Steel Forgings and Billets (H. P. Tiemann, chairman).—A section of this subcommittee, under the chairmanship of Mr. W. M. Barr, has prepared new proposed Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives which are being recommended for publication as tentative. These specifications, which are appended hereto,[1] have been developed in line with changes and advances in the use of alloy-steel forgings for locomotives. The use of alloy steels is, in the opinion of Subcommittee VI, sufficiently uniform to warrant the promulgation of tentative specifications covering such material.

Revisions clarifying the "boring clause" in the forging specifications are being recommended by this subcommittee, as given in the Appendix, in the Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19 – 27), for Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 63 – 27), and Tentative Specifications for Carbon-Steel Forgings for Locomotives (A 20 – 29 T).

Subcommittee VIII on Steel Castings (W. C. Hamilton, chairman).—Subcommittee VIII is considering specifications for alloy-steel castings and is collecting data from various technical societies as to types and requirements of alloy castings.

This subcommittee is cooperating with the American Foundrymen's Association in the development of a symposium to present to engineers critical data regarding analyses, heat treatment, and methods of molding and casting to produce the most desirable properties in various types of steel castings.

A section on standardization of A.S.T.M. casting specifications is actively at work.

Subcommittee IX on Steel Tubing and Pipe (H. H. Morgan, chairman).—This subcommittee has been very actively engaged in preparing new specifications for five different types of fabricated pipe: namely, Specifications for Riveted Steel and Wrought-Iron Pipe, for

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[1] See p. 668.—ED.

Lock-Bar Steel Pipe, for Forge-Welded Steel Pipe, for Electric-Resistance-Welded Steel Pipe, and for Electric-Fusion-Welded Steel Pipe. These specifications will come up for consideration at a meeting of Committee A-1 to be held during the annual meeting and if approved will be subsequently submitted to Committee E-10 on Standards during the current year for publication as tentative.

This subcommittee also has under consideration, as the result of a request from the Boiler Code Committee of the American Society of Mechanical Engineers, the development of requirements for steel tubes having a higher carbon content and corresponding physical properties than those at present included in the Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 30).

Subcommittee XI on Boiler Steel (E. J. Edwards, chairman).—Subcommittee XI is considering the requirements for a high tensile strength boiler plate and has reorganized the sub-subcommittee to assemble existing information and data on this type of material.

Subcommittee XIII on Methods of Physical Tests (L. H. Fry, chairman).—This subcommittee has been inactive during the year. The chairman, Mr. T. D. Lynch, has resigned because of pressure of other duties and Mr. L. H. Fry has been appointed chairman.

Subcommittee XIV on Tool Steel (M. E. McDonnell, chairman).—In cooperation with Committee B-6 on Die-Cast Metals and Alloys, this subcommittee is considering requirements for steel for die casting. No definite steps looking toward the preparation of specifications for such material until the joint committee has assembled available data on this subject.

Subcommittee XIX on Sheet Steel and Steel Sheets (J. M. Darke, chairman).—Subcommittee XIX is cooperating with the Pressed Metal Institute on a program of investigating steel for deep drawing requirements. A section of the subcommittee has made some progress in the development of specifications for steel sheets for cars.

This subcommittee recommends that the Tentative Specifications for Cold-Rolled Strip Steel (A 109 – 27 T), which have been tentative for over three years without revision, be continued as tentative for another year pending the outcome of tests on standard test specimens recommended by Committee E-1 on Methods of Testing.

Subcommittee XXI on Steel for Welding (F. N. Speller, chairman).—As a result of a request from the Boiler Code Committee of the American Society of Mechanical Engineers for a specification for steel plates of firebox quality for forge welding, this subcommittee has prepared proposed Tentative Specifications for Steel Plates of Flange and

Firebox Qualities for Forge Welding, appended hereto,[1] which are recommended for publication as tentative. These specifications are in effect a revision of, and will supersede when adopted, the present Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A 89 – 30). The new proposed tentative specifications are identical with the standard specifications except for the addition of requirements for firebox quality material, the inclusion of requirements for elongation in 2 in. for material over 1½ in., and the elimination of the requirement that the steel should preferably be free from nickel.

A Symposium on Welding held in conjunction with the Regional Meeting at Pittsburgh in March presented to the Society and to the American Welding Society representatives, assembled with them, the latest developments on methods of welding and testing welds. Subcommittee XXI cooperated in the development of this symposium and sponsored a paper on materials for welding.

The subcommittee is making a survey of existing specifications, practices, and patents on welding wire before considering the development of specifications for this product.

Subcommittee XXI has decided to supplement the list of specifications published in the 1930 report[2] suitable for fusion welding and to add a note suggesting a maximum 0.30 per cent carbon. The action of the subcommittee, together with the revised list of specifications, is as follows:

1. It was voted that it is not necessary at present to write separate and complete specifications for steel for fusion-welding, in view of the number of existing standard specifications under which satisfactory material has been purchased for this purpose.

2. It was voted as the opinion of Subcommittee XXI that steel made under the following A.S.T.M. specifications can be welded satisfactorily by the usual fusion process now in general use:

Standard Specifications for Structural Steel for Bridges (A 7 – 29);
Standard Specifications for Structural Steel for Buildings (A 9 – 29);
Standard Specifications for Structural Steel for Locomotives and Cars (A 113 – 29);
Standard Specifications for Structural Steel for Ships (A 12 – 21);
Standard Specifications for Boiler and Firebox Steel for Locomotives (A 30 – 24);
Standard Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 27);
Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30);

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[1] See p. 648.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 86 (1930).

Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A 89 – 30);

Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 31 T);

Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 27);

Standard Specifications for Welded and Seamless Steel Pipe (with Carbon Restriction) (A 53 – 30);

Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 27);

Standard Specifications for Lap-Welded and Seamless Steel Pipe for High-Temperature Service (A 106 – 29);

Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses (A 120 – 28 T);

Tentative Specifications for Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T).

In connection with carbon limitations in the above specifications, the committee was of the opinion that, while higher carbon steels are successfully welded, commercial practice at present often limits the carbon (by ladle test) to 0.30 per cent in open-hearth steel and 0.15 per cent in bessemer steel. In the case of seamless steel pipe covered by Specifications A 53, the carbon limit was placed at 0.35 per cent (this would apply to transverse welds).

The subcommittee has decided to add to the list of specifications suitable for fusion-welding, the new specifications prepared by Subcommittee II for structural steel for buildings and bridges having a tensile strength range of 60,000 to 72,000 pounds per square inch.[1]

The subcommittee is recommending, as given in the Appendix, the removal of the maximum limits on nickel content in the case of material for fusion welding only as a tentative revision of the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30).

Subcommittee XXII on Valves, Fittings, Piping and Flanges for High-Temperature Service (L. W. Spring, chairman).—Subcommittee XXII is recommending, as given in the Appendix, revisions for immediate adoption in the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27), and also the adoption of the tentative revision proposed last year.[2]

The subcommittee is also considering specifications for steel for temperatures over 750° F.

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[1] The use of these specifications is limited to material $\frac{3}{4}$ in. or under as it felt that the carbon content in heavier material may run over the suggested maximum limit of 0.30 per cent.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 91, 1270 (1930).

This report has been submitted to letter ballot of the committee, which consists of 189 members; 121 members returned their ballots, of whom 120 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

J. B. YOUNG,
Chairman.

V. H. LAWRENCE,
Secretary.

[For a discussion on the Report of Committee A-1, see page 101.—ED.]

EDITORIAL NOTE

The proposed Tentative Specifications for Normalized and Tempered Alloy-Steel Forgings for Locomotives and for Steel Plates of Flange and Firebox Qualities for Forge Welding were accepted for publication as tentative and appear on pages 668 and 648, respectively.

The proposed immediate revision, and advancement to standard of the tentative revision proposed in 1930, of the Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service was approved at the annual meeting by a unanimous vote and was subsequently adopted by letter ballot of the Society on September 1, 1931. The specifications in their revised form appear in the 1931 Supplement to Book of A.S.T.M. Standards, page 9.

The proposed revisions of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars, for Quenched-and-Tempered Carbon-Steel Axles, Shafts and Other Forgings for Locomotives and Cars, for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars, for Steel Tie Plates, for Steel Plates of Structural Quality for Forge Welding and for Structural Silicon Steel were accepted and approved for publication as tentative and appear on pages 1040, 1042, 1042, 1042, 1043 and 1039, respectively.

The proposed revision of the Standard Specifications for Rail-Steel Concrete Reinforcement Bars proposed on the floor of the annual meeting, as mentioned in the Summary of Proceedings, page 25, was also accepted and appears on page 1041.

The proposed revisions of the Tentative Specifications for Carbon-Steel Forgings for Locomotives and for Heat-Treated Carbon-Steel Helical Springs were accepted. The specifications in their revised form appear on pages 662 and 654, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this Appendix are given proposed revisions in certain standard and tentative specifications. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

PROPOSED REVISION OF STANDARDS

Group A. Recommended for Immediate Adoption

Standard Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 27):[1]

Section 1.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

> 1. (*a*) These specifications cover alloy-steel bolting material for *pressure vessels,* valves, flanges, and fittings for high-temperature service (see Explanatory Note).

Change Paragraph (*b*) to read as follows by the addition of the italicized words:

> (*b*) Three classes of material are covered, A, B, and C, classified in accordance with their physical properties as specified in Section 10, *choice depending upon design and upon the stresses and service for which the material is to be used.*

Section 10 (*a*).—The present requirements in the table following Paragraph (*a*) apply to bolting material 2½ in. and under. It is recommended that the following additional requirements be added to this table covering bolting material over 2½ to 4 in., inclusive, and over 4 to 7 in., inclusive:

DIAMETER, IN.		CLASS A	CLASS B	CLASS C
Over 2½ to 4, inclusive	Tensile strength, lb. per sq. in..	90 000	100 000	115 000
	Yield point, lb. per sq. in.......	65 000	75 000	95 000
	Elongation in 2 in., per cent....	20	20	16
	Reduction of area, per cent.....	50	50	45
Over 4 to 7, inclusive.	Tensile strength, lb. per sq. in..	90 000	100 000	110 000
	Yield point, lb. per sq. in.......	65 000	75 000	85 000
	Elongation in 2 in., per cent....	20	20	16
	Reduction of area, per cent.....	50	50	45

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 269.

Group B. Recommended for Publication as Tentative

Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30):[1]

Section 3 (b).—Change to read as follows by the addition of the italicized words:

(*b*) The bars shall be rolled from new billets *of properly identified heats of open-hearth or lots of bessemer steel.* No rerolled material will be accepted

Section 11 (a).—Change from its present form: namely,

11 (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

11. (*a*) Tension and bend test specimens for plain and deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars as rolled the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece (see Note).

In case it is necessary to determine the tensile or bending properties of the bars without regard to the[2] design, the specimen shall be machined to a uniform cross-section for a length of at least 9 in.

NOTE.—By this method the area in square inches may be obtained by dividing the weight, in pounds per inch of specimen length, by 0.2833 (weight of 1 cu. in. of steel); or by dividing the weight in pounds per foot of specimen length by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 13.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

13. The weight of any lot of bars shall not vary more than 5 per cent [from] *over or under* the theoretical *or specified* weight of that lot. *The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars ⅜ in. and less.*

New Section.—Under a new central heading "Marking," add the following paragraph as a new Section 15, renumbering the present sections accordingly:

15. *Marking.*—The brand of the manufacturer shall be legibly rolled on all deformed bars, and when loaded for mill shipment all bars shall be properly separated and tagged with the manufacturer's test identification number.

Standard Specifications for Rail-Steel Concrete Reinforcement Bars (A 16 – 14):[3]

Section 7 (a).—Change from its present form: namely,

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 131.

[2] This word changed to "their" by action at the annual meeting.—ED.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 135.

7. (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

7. (*a*) Tension and bend test specimens for plain and deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars as rolled the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece (see Note).

In case it is necessary to determine the tensile or bending properties of the bars without regard to their design, the specimen shall be machined to a uniform cross-section for a length of at least 9 in.

NOTE.—By this method the area in square inches may be obtained by dividing the weight, in pounds per inch of specimen length, by 0.2833 (weight of 1 cu. in. of steel); or by dividing the weight in pounds per foot of specimen length by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 9.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

9. The weight of any lot of bars shall not vary more than 5 per cent [from] *over or under* the theoretical *or specified* weight of that lot. *The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over* $\frac{3}{8}$ *in. in diameter; nor more than 12.5 per cent over or under for bars 3.8 in. and less.*

Standard Specifications for Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19 – 27)[1] *and for Quenched-and-Tempered Alloy-Steel Axles, Shafts and Other Forgings for Locomotives and Cars (A 63 – 27):*[1]

Section 5.—Change from its present form: namely;

5. (*a*) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring shall be done before quenching.

(*b*) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

to read as follows:

5. (*a*) Unless otherwise specified by the purchaser, all axles, shafts, and similar forgings having a minimum diameter over 7 in. shall be bored. The boring shall be done before quenching.

(*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter of the forging, exclusive of collars and flanges.

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[1] 1930 Book of A.S.T.M. Standards, Part I, pp. 186 and 193, respectively.

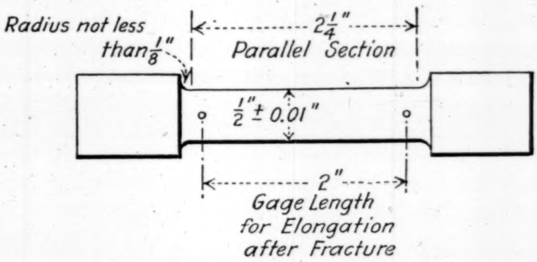
Standard Specifications for Steel Tie Plates (A 67 – 30):[1]

Section 3 (a).—Add the following requirement for copper to the requirements for chemical composition:

Copper, when copper steel is specified, per cent..........not under 0.20.

Section 4.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

4 (*a*) A carbon determination shall be made of each melt of bessemer steel, and three analyses every 24 hours representing the average of the elements carbon and phosphorus, *and also copper when copper steel is specified*, contained in the steel, one for each 8-hour turn respectively.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

Change the first sentence of Paragraph (*b*) to read as follows by the addition of the italicized words:

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon and phosphorus; *also copper when copper steel is specified.*

Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 – 30):[2]

Section 3 (b).—Add a reference to the word "nickel" in this section referring to the following footnote:

When these specifications are used for material to be fusion welded, the maximum limit for nickel shall not apply.

Standard Specifications for Structural Silicon Steel (A 94 – 29):[3]

Section 7 (a).—In the table following this paragraph after the requirement for elongation in 8-in., insert a requirement for elongation in 2-in., as follows:

Elongation in 2 in., minimum, per cent.......................... $\frac{1\,600\,000}{\text{tens. str.}}$

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 63.

[2] *Ibid.*, p. 122.

[3] *Ibid.*, p. 80.

Section 8.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. in thickness or diameter below $\frac{5}{16}$ in.

Section 11 (*e*).—Change to read as follows by the addition of the italicized words and dimension and the omission of the dimension in brackets:

(*e*) Tension test specimens for material over [1] *1½* in. in thickness or diameter may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in. *or they may conform to the dimensions shown in Fig. 2.*

Figure 2.—Add as Fig. 2 the accompanying Fig. 1.

PROPOSED REVISIONS OF TENTATIVE STANDARDS

Tentative Specifications for Carbon-Steel Forgings for Locomotives (A 20 - 29 T):[1]

Section 6.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

6. If boring is [specified] *required in the case of axles, shafts and similar forgings*, it shall be performed before heat treatment, and the diameter of the hole, *unless otherwise specified*, shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

Section 16.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

16. The forgings shall conform to the sizes and shapes specified by the purchaser. *Axles, shafts and similar forgings, unless otherwise specified, shall be rough-turned all over with an allowance of* $\frac{1}{8}$ *in. on the surface for finishing.* [When centered] *In centering*, 60-deg. centers with clearance drilled for points shall be used.

Tentative Specifications for Heat-Treated Carbon-Steel Helical Springs (A 125 - 29 T):[2]

Section 6 (*a*).—In the table following this paragraph change the requirement for silicon content to read as follows by the addition of the italicized word and the omission of the word and figure in brackets:

Silicon, *minimum*, per cent.................................... 0.15 [to 0.30]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 555 (1929); also 1930 Book of A.S.T.M. Tentative Standards, p. 42.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 566 (1929); also 1930 Book of A.S.T.M. Tentative Standards, p. 34.

DISCUSSION

[Mr. J. B. Young, in presenting the Report of Committee A-1 on Steel, recommended the acceptance for publication as tentative of the proposed revisions of the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30), including the following rewording of Section 11 (*a*):

> 11. (*a*) Tension and bend test specimens for plain and deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars as rolled, the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece.
>
> In case it is necessary to determine the tensile or bending properties of the bars without regard to the design, the specimen shall be machined to a uniform cross-section for a length of at least 9 in.

This recommendation was discussed as recorded below.—Ed.]

Mr. W. A. Slater.[1]—The old clause permitting the machining of deformed bars for the purpose of making tension and bend tests has been before the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete since about 1921. The Joint Committee in its 1921 report[2] adopted the A.S.T.M. specifications except that that particular provision was eliminated, and I understand that a good many other bodies in writing building codes and specifications have taken similar action. Representations have been made to Committee A-1 on Steel to have that clause removed from the A.S.T.M. specifications, so that the entire specification could be adopted by the Joint Committee without any exception. Believing that the revised clause being proposed by Committee A-1 was nearly the same in effect as the old provision, the Joint Committee in session yesterday passed the following resolution:

> Resolved, that the Joint Committee request the American Society for Testing Materials to reconsider the tentative revisions of its Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30) with the object of eliminating the clause permitting the machining of test specimens for determining the physical properties of deformed bars.

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[1] Research Professor of Engineering Materials and Director, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

[2] Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 212 (1921).

I understand from conversation with Mr. Morgan the chairman of the subcommittee having jurisdiction over the specifications that the intention was to eliminate that clause except for certain cases in which the results of tests were to be used in determining the properties of the material rather than of the finished bar, but I do not think the wording of it makes it clear that this is the case. It seems to me that in case of dispute, it would be entirely impossible from the wording used, to determine the circumstances under which the bar should be machined before testing. If this clause is retained at all, it should be made more specific and more clear as to what the purpose is and in what cases it controls, and to make it clear that the acceptance or rejection of a reinforcement bar is to be based upon the test of the bar as rolled and without any machining.

MR. J. O. LEECH.[1]—If you take the last clause of the proposed paragraph: "in case it is necessary to determine the tensile or bending properties of the bars without regard to the design,"—that is one thing. But the revised paragraph reads that the: "tension and bend test specimens for plain and deformed bars shall be of the full section of the bars as rolled;" and then goes on to state that: "in case it is necessary to determine the tensile or bending properties of the bars without regard to the design of the bar, the specimen shall be machined." The latter clause is simply put in as an arbitration clause in case of dispute. That is all it is for. The intent of the revision is that acceptance tests, tension and bend, of both plain and deformed bars shall be of the full section of the bars as rolled.

MR. SLATER.—In Mr. Leech's reading of this clause, he inserted the words which perhaps would go a long way toward making it clear; he read it, "in case it is necessary to determine the tensile or bending properties of the bars without regard to the design *of the bar*, the specimen shall be machined." The words "of the bar" are not there. When I first read the clause, I supposed it meant without regard to the design of the structure in which the bar is used. I have talked to others who thought it meant the same thing. The addition of those words makes a big difference, but even that does not clear up the doubt as to the circumstances under which that provision applies.

MR. LEECH.—I do not see how you can interpolate a finished structure in a bar specification.

MR. H. H. MORGAN.[2]—I think Mr. Slater's point on that is well taken. If anybody can put that interpretation on it, we can just as well put "the design of the bar" in there.

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[1] Manager, Bureau of Inspection and Tests, Carnegie Steel Co., Pittsburgh, Pa.

[2] Manager, Rail and Fastenings Department, Robert W. Hunt Co., Chicago, Ill.

MR. LEECH.—That was certainly the intent. No one expected that a bar specification would refer to the design of the building.

MR. SLATER.—I still do not think it is clear, because if you say it shall be tested as rolled and then give another provision later under which it may be tested in some other way, without stating the conditions specifically under which each provision controls, the result is confusion.

MR. LEECH.—We cannot provide in a specification of this kind for every contingency that may arise. It reads: "in case it is necessary." It seems to me that that is as explicit as necessary.

MR. J. J. SHUMAN.[1]—I am sure Mr. Slater has no intention of blocking a good move. There are a number of us on this reinforcement bar committee who have worked to check the abuses that exist in interpreting the specifications and to preserve the use of the A.S.T.M. specifications for reinforcement bars as the general and prevailing specifications. We have worked hard to get this very paragraph in there. It was necessary that something of the kind be put in because of the conditions that exist in the industry, namely, that some mills are simply rolling bars for the proprietors of those bars, they are not interested beyond meeting the specifications on the mill tests. They certainly should not put themselves in the position of guaranteeing the tests after those bars are sold out of the warehouse to the consumer, so it was necessary to put something like this in there to safeguard the mills; so that if it became a question of whether the right quality of steel was rolled into these deformed bars, then there would be a paragraph in the specifications that provides for turning off the deformations comprising the design of the bar and getting down to the steel itself. Now, if we should fail to approve a good move like that, we shall be not only damaging the standing of the specifications, but actually going back to a condition that has been almost intolerable, and, as Mr. Slater says, has been a subject of controversy for ten years. Now I am convinced that the right thing to do is to approve these changes for publication as tentative, just as presented, then the subcommittee taking this discussion into consideration can fix this up so that by the time it comes up for final adoption it will be right.

MR. MORGAN.—As the chairman of the subcommittee having jurisdiction over these specifications I want to say that I represent consuming interests and am primarily interested in getting these specifications in the best shape in the most effective manner. I am convinced that the clause offered is an effective way of doing this; it is offered as tentative and will be subject to revision during the coming year. If we turn down these tentative revisions, we go back to the old requirement. Every one will admit that these revisions are a distinct advancement. It may not satisfy every individual's ideas of how that revision should be written, but there is no individual who is writing any specification of the Society.

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[1] Inspecting Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

MR. SLATER.—It is true that I have no intention of doing anything to block progress, but I do not believe that any progress is represented. As has been stated, it may be important that certain provisions be included to help the relations between the manufacturer and the distributor but they have that provision in the old specifications. If the present proposal is not approved, as Mr. Morgan has said, it will merely go back to the old specification, and the relations between the manufacturer and the distributor are properly protected there. If this really represented any progress, I should certainly be in favor of it. Apparently the difficulty is purely a failure to make clear what was intended in this provision, and until the provision is made clear so that it will really represent progress, I think it should be disapproved.

MR. J. B. YOUNG[1] (*Chairman, Committee A-1*).—I should like to call attention to the fact that if this recommendation is not approved it will not appear in any of the publications of the Society, and in that way it will not be before the Society for any criticism. If the chairman may express an opinion, I feel that it is an advance.

MR. LEECH.—All one has to do is carefully to compare the present wording with the proposed revision to see that there has been a change and an improvement.

> [The motion to accept the proposed revisions for specifications as tentative was adopted after the phrase "without regard to the design" had been changed to read "without regard to their design."—ED.]

SUBSEQUENT DISCUSSION BY LETTER

MR. SLATER (*by letter*).—A proposed amendment prepared by the late S. T. Wagner and the writer representing the Society's Committee C-2 on Reinforced Concrete, consists of inserting in Section 11 (*a*) after the first sentence the words "The acceptance of the bars for use as reinforcement shall be based upon the result of these tests," and changing the words "the bars without regard to their design" in the second paragraph to "the steel from which the bar was rolled."

This proposed amendment has been submitted to the members of Committee C-2 and to the members of the Joint Committee on

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[1] Engineer of Tests, Reading Co., Reading, Pa.

Standard Specifications for Concrete and Reinforced Concrete for an informal ballot. Of the combined membership of 42 in these two committees, 21 members have expressed themselves in favor of the proposition that in all cases the acceptance of the bars for use as reinforcement shall be based upon the results of the tests of the bars as rolled and one has withheld judgment upon this proposal. Two have opposed the provision for any test of the bar after machining. The other members have not voted.

This amendment was prepared in the belief that the provision for a test of the machined bar as a test of the material in addition to the acceptance test of the bar as rolled would be acceptable to the proprietors and distributors. If this belief is not well founded (as it now seems may be the case), the writer would not be in favor of such a provision.

The ballot did not call for an expression upon the subject of the manner of determining the sectional area, but one member expressed approval of making this determination by weight in the manner proposed by Committee A-1.

MR. W. S. THOMSON[1] (*by letter*).—If the amendment proposed by Mr. Slater is adopted, the specifications would seem to convey a double meaning to the distributor: one in his relations with the mill and the other in his relations with the ultimate user. In the first case the machining clause may be invoked, while in the other it is ruled out. This places the distributor in the position of having to purchase his material under a liberal interpretation of the specifications and reselling the identical material under a restricted interpretation. The requirements should be the same for distributor as for ultimate user.

If a mill objects to certain features in the design of any particular bar from the standpoint of mill practice, it is naturally their privilege to register their objections with the proprietor of the bar, in order that adjustments may be made to their mutual satisfaction. Once these differences have been adjusted, however, and the bar accepted for rolling, it would seem imperative that all tests be made on the bar as rolled.

MR. MORGAN (*Chairman, Subcommittee V, Committee A-1, by letter*).—The above discussions by letter submitted by Messrs. Slater and Thomson subsequent to the annual meeting of the Society have been referred to Committee A-1 on Steel and to Subcommittee V on Reinforcement Bars for consideration. They will receive the attention of the subcommittee during the coming year.

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[1] Civil Engineer, Evanston, Ill.

REPORT OF JOINT RESEARCH COMMITTEE
ON
EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PROGRESS REPORT TO THE SPONSOR SOCIETIES

Membership and Business Meetings.—With one or two exceptions, the membership of the committee has remained the same as it was in June, 1930. Three meetings were held during the past year, one at Atlantic City in June, 1930, and two at the headquarters of the American Society of Mechanical Engineers in New York in December, 1930, and February, 1931.

Technical Meetings and Papers Sponsored by the Committee.—One of the important activities of the Joint Committee may be considered to be the sponsorship of technical meetings or of reports of original researches relating to the effect of temperature on the properties of metals.

During the past year the following papers were presented under the sponsorship of the committee before meetings of the American Society of Mechanical Engineers:

"Flow of Steel at High Temperatures," by F. H. Norton, Presented at National Petroleum Division (A.S.M.E.) Meeting, Tulsa, Okla., October 6–8, 1930.

"Properties of Non-Ferrous Alloys at Elevated Temperatures," by C. L. Clark and A. E. White, presented at A.S.M.E. Annual Meeting, December 1–5, 1930.

"Comparative Physical Properties of Chromium-Nickel, Chromium-Manganese, and Manganese Steels," by C. L. Clark and A. E. White, presented at A.S.M.E. Annual Meeting, December 1–5, 1930.

Two additional papers are also being presented under the Joint Committee auspices at the June, 1931, Annual Meeting of the American Society for Testing Materials. These papers, which are appended hereto, are as follows:

"Apparatus for Low-Temperature Endurance Testing," by H. W. Russell and W. A. Welcker, Jr., appearing as Appendix II to this report;

"New Creep Testing Apparatus at the Massachusetts Institute of Technology," by F. H. Norton and J. B. Romer, appearing as Appendix III to this report.

Another important item in the activities sponsored by the Joint Committee, and one of widespread interest, is the forthcoming symposium[1] to be held at a joint meeting of the sponsor societies in Chicago, June 23, 1931.

In rapidly expanding fields of activity, as for example, those involving the application of metals at high and low temperatures, much progress is made each year and it becomes useful, at intervals, to take stock of our knowledge and perhaps also to appraise recent accomplishments. An effective means of achieving these objects is to collect essays from different sources as the basis for discussion, that is, the free interchange of information or ideas relating to all phases of the subject.

Interchange of information or ideas requires joint effort and the coordination of activities of this sort only can be directed successfully by some agency familiar with the field and its workers and one which is representative of the different interests involved.

The preparations for the symposium have required much effort by the authors of papers, by the committee and by the sponsor societies. In view of the great interest in the effect of temperature on the properties of metals and the large amount of data assembled as the basis of discussion, a novel scheme has been proposed by the Joint Committee and will be tried in conducting the meetings. Briefly, the thirty odd papers to be presented at the two technical sessions will not be read by the respective authors. Instead, two members of the Joint Committee, not themselves authors, have been selected to abstract, in a broad way, the papers to be presented at the two sessions. All but about 30 minutes required for each of these abstracts will thus be available for the discussion which generally forms such a valuable part of technical meetings. It is hoped that this plan will prove to be successful enough to inspire others to apply it.

Sponsored Researches Relating to the Fatigue of Metals at High Temperatures.—Some years ago, the Joint Committee undertook cooperative researches relating to flow (creep) in metals at different temperatures. Discussions since that time brought a realization of the need for the comparison of the effects of sustained loading (creep tests) and repeatedly applied stresses (endurance tests) on metals at different temperatures.

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[1] See Symposium on Effect of Temperature on the Properties of Metals published jointly in 1931 by the American Society for Testing Materials and the American Society of Mechanical Engineers.

While correlations of this sort have been made in a limited way, it is not yet practicable to state with certainty whether or not the limiting conditions at high temperatures are the repeatedly applied stresses, as at atmospheric temperatures, or whether failure is liable to occur the more readily under sustained loading. The temperature ranges within which metals may be expected to fail the more readily by fatigue or by creep are not now known accurately for even the most generally used of the commercial alloys.

During 1927 and 1928 a fund of some $2000 was collected for the support of preliminary work in this field. The organizations contributing to this fund were:

Allis Chalmers Manufacturing Co., Milwaukee, Wis.,
American Brown-Boveri Electric Co., Camden, N. J.,
American Society of Mechanical Engineers Research Committee, New York City,
General Electric Co., Schenectady, N. Y.,
Terry Steam Turbine Co., Hartford, Conn.,
B. F. Sturtevant Co., Inc., Boston, Mass.,
Westinghouse Electric and Manufacturing Co., Lester Station, Philadelphia, Pa.

Arrangements were made with the University of Illinois, Urbana, Ill., to carry out repeated stress (fatigue) tests at different temperatures on a steel previously subjected by the Joint Committee to flow (creep) tests.

A low-carbon steel, such as is used in boiler construction, was selected for these preliminary tests and there is now submitted to the sponsor societies, as Appendix I to this report, a preliminary report of the endurance tests carried out at the University of Illinois by Messrs. H. F. Moore and N. J. Alleman, entitled "Progress Report on Fatigue Tests of Steel at Elevated Temperatures."

The development of the test methods and the actual test work in this sponsored project were carried out under the guidance of a fatigue subcommittee (H. W. Gillett, chairman) of the Joint Committee's Committee III on Projects and Work (L. W. Spring, chairman).

Other Committee Research Activities.—Along with its other activities, the Joint Committee has carried on quite actively a program of research where the tests have been made by members of the Joint Committee or by the organizations with which they are associated.

A progress report for such work is appended hereto by Committee III on Projects and Work (L. W. Spring, chairman), but it may be of interest at this point to call attention to three phases of the work now under way.

A good start has been made in tests designed to compare the mechanical properties and structural stability of cast and wrought steels. Already there is also well advanced a study of the effect of long-time heating upon the mechanical properties and structural stability of stainless steels containing 18 per cent chromium, 8 or 10 per cent nickel and different proportions of carbon. Progress can also be reported in the development of a test code for high-temperature tension tests.

Detailed technical reports covering all three of these projects may be expected during the coming year.

Finance.—It was pointed out in the 1930 report[1] to the sponsor societies that the proposed extensions to the Joint Committee's research program made it necessary to secure adequate financial support so that the full time services of both men and equipment might become available for certain plans of the Joint Committee's work.

During the year a brochure covering the aims and activities of the Joint Committee was prepared for use in the solicitation of funds. While the goal set was not attained, due partly to illness of committee members but perhaps more directly to unfavorable business conditions during the greater part of the year, contributions totaling nearly one-half of the total amount of money desired have been promised *provisional upon the procurement of the balance.*

Therefore, progress may be reported in this phase of the Joint Committee's activities, but the membership of the sponsor societies should not interpret this to mean that the committee's plans can be carried out without appreciable added financial support.

Respectfully submitted on behalf of the Joint Committee,

H. J. FRENCH,
Chairman.

N. L. MOCHEL,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 93 (1930).

A series of fatigue tests have been made on a 0.17-per-cent carbon open-hearth steel and are being reported in a paper by H. F. Moore and N. J. Alleman which appears as Appendix I. The work was done at the University of Illinois under the supervision of Subcommittee F (H. W. Gillett, chairman) and under the immediate direction of Mr. Moore. This material, known as K1, was tested four years ago by four different cooperating laboratories which reported on its short-time tensile properties.[1] Data on thermal expansion also has been reported.[2] The present fatigue tests, together with the previously reported data, including complete creep tests contributed by one laboratory, comprise an extensive correlation of the mechanical properties at high temperatures for mild, normalized, open-hearth steel.

Steel K9:

Chromium-nickel steels of 18 per cent chromium and 8 per cent nickel, one lot with carbon less than 0.07 per cent and one lot with carbon 0.08 to 0.12 per cent, were obtained, and cooperative tests by the three Subcommittees G, M and O are almost completed. These two steels in the form of $\frac{5}{8}$-in. square rolled rod were provided respectively by two different manufacturers. As submitted for test, the steels were in three different conditions of heat treatment as follows: (*a*) as rolled; (*b*) water quenched from 2100° F.; (*c*) air quenched from 1950° F. A series of six 1000-hour tempering treatments was subsequently applied to each lot of steel. These steels are known as K9c and K9d, each of the 18 treatments (36 total) being designated by a further system of symbols.

Steel K6:

Cast and wrought open-hearth steel, both from one heat with 0.30 per cent carbon, also have been secured. These have been heat treated and are now being machined preparatory to testing cooperatively by Subcommittees C and D. Each of the cast and wrought portions has been furnished in two heat treatments annealed and normalized. The tests, therefore, will be representative of 0.30-per-cent carbon steel in a total of four different conditions. Tests on this material were projected primarily to investigate the effect of working and of grain size upon the tensile and creep properties of medium-carbon steel, as compared to the cast variety of the same composition.

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[1] Report of Joint Research Committee on Effect of Temperature on the Properties of Metals, Appendix I, "Preliminary Report on Comparative High Temperature Tension Tests on a Carbon Steel and on a Chromium Molybdenum Steel at Different Laboratories," *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 143 (1927).

[2] *Ibid.*, Appendix II, "Report on Thermal Expansion of Materials," p. 153.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee A on Materials Procurement, Treatment and Distribution.—The materials described above were furnished by this subcommittee. Unfortunately J. A. Mathews who is chairman of Subcommittee A has been ill and has been forced to give up his duties on Committee III. For the time being, the work of procurement and distribution is being carried forward by several members of Committee III.

Subcommittee C on Development of Reference Test Method (A. E. White, chairman).—This subcommittee has reported a reference method on tension tests whereby it is hoped that investigators testing similar materials by this method, even those who have had little or no experience in high-temperature testing, may be able to get reasonably concordant results. Tests being made at present at various laboratories are somewhat in conflict because of the varied practice in determining temperatures, design of extensometer, methods of applying heat, etc. It will be the task of this subcommittee to determine upon the best or optimum practice that can be adopted in each phase of testing technique where there now exists a variety of practices.

Subcommittee D on Short-Time Tensile Tests (H. J. Kerr, chairman).—Subcommittee D has tentatively adopted a procedure for short-time tensile tests. Tests will be made on steel K6, case and wrought materials of the same heat of steel (0.30-per-cent carbon open-hearth steel) by this subcommittee which, it is expected, will be followed later by tests on K9 material (18 per cent chromium, 8 per cent nickel with carbon below 0.07 per cent and with carbon above 0.07 per cent). At the present time efforts are being made to expedite the distribution of K6 material as the results of this investigation are of considerable interest and importance in connection with the heat treatment of carbon steels. Short-time tension testing in the past few years has come to be regarded by some as of questionable worth, particularly for design purposes. It will be the task of Subcommittee D to decide the extent to which such an appraisal is merited. It is the feeling in many quarters that a short-time high-temperature test is not only of considerable value for the comparison of materials but up to a "limiting" temperature gives constants of engineering significance.

Subcommittee E on Long-Time Tensile Tests (C. E. MacQuigg, chairman).—Subcommittee E has drafted a tentative code for long-time tensile or creep tests. The subcommittee will make creep tests on material K6 listed above, cast and wrought steels from the same heat. This, it is expected, will be followed by tests on 18 per cent chromium, 8 per cent nickel alloy with low and high carbon, paralleling the program of Subcommittee D. Test specimens of steel K6 are at the present time being prepared and distributed among six laboratories which will make creep tests intended to demonstrate the characteristic differences existing in creep phenomena above and below the so-called equi-cohesive temperature. This project is expected to show whether above the equi-cohesive temperature, cast steels and steels which have been heat treated to give large grain size, resist creep to a greater extent than those with small grain size as, for example, worked steels.

Subcommittee F on Fatigue Tests (H. W. Gillett, chairman).—This subcommittee has sponsored fatigue tests at the University of Illinois under H. F. Moore as mentioned earlier in this report and reported upon in Appendix I. Further work by the subcommittee upon fatigue of metals is contingent upon the procurement of funds such as were contributed for the execution of the present tests reported by Moore and Alleman.

Subcommittee G on Impact Tests (C. L. Kinney, Jr., chairman).—Subcommittee G is practically ready to report cooperative impact tests which were made at four different laboratories on steels K9c and K9d (18 per cent chromium, 8 per cent nickel) of 36 different heat treatments briefly referred to above. Since the two materials, K9c and K9d differ in composition in such a manner involving a commercial aspect in the manufacture of 18 per cent chromium, 8 per cent nickel alloy, these results will be of practical interest to metallurgists, consumers and makers.

Subcommittee H on Elastic Measurements and Shear (P. H. Brace, chairman).—This subcommittee is considering various methods for determining elastic properties of metals at elevated temperatures, such as proportional limit, Young's modulus of elasticity, torsional modulus of elasticity, and Poisson's ratio. There is considerable need for development of precise methods and determination of accurate data upon these constants, particularly at elevated temperatures.

Subcommittee J on Service Data (A. D. Bailey, chairman).—Subcommittee J has circulated a questionnaire for service data on metals among its fourteen members representing the steam, oil and chemical industries. A detailed report has not been made as yet. It is apparent that all of the new stainless types of alloys have not been meeting with entire success in the oil industry and merits of the newer alloys as determined by practical use are awaited with interest. Indications are that it will be some time before concordant reports are obtained.

Subcommittee K on Thermal Expansion (N. L. Mochel, chairman).—Material is being provided for thermal expansion determinations upon steels K6 and K9. A comprehensive digest of the available data on thermal expansion has been contributed by N. L. Mochel in a paper entitled "Thermal Expansion of Metals"[1] in the Joint A.S.M.E. and A.S.T.M. Symposium on Effect of Temperature on the Properties of Metals presented at this annual meeting of the Society.

Subcommittee M on Metallography and Structural Stability (Louis Jordan, chairman).—This subcommittee is engaged in cooperative investigation at four different laboratories upon the structure of the K9c and K9d steels of 36 different heat treatments described above as being tested by Subcommittee G on Impact Tests. One or more photomicrographs upon each of the 36 heat treatments is being prepared at each of the cooperating laboratories. It is expected that this metallographic study will check up with studies on these identical materials by Subcommittee G on Impact Tests and Subcommittee O on Chemical Stability, and will indicate the amount of carbide precipitation, changes in microstructure, etc., which have been brought about by the various heat treatments. Incidentally, this work should aid in the development of metallographic technique for examining this type of alloy.

Subcommittee N on Wear and Seizure (V. T. Malcolm, chairman).—This subcommittee has made no report as yet. It is anticipated, however, that an investigation upon wear resistance of nitrided steel at elevated temperatures, and perhaps others, will be undertaken.

Subcommittee O on Chemical Stability (Jerome Strauss, chairman).—Subcommittee O is engaged in cooperative investigations at four different laboratories upon corrosion tests of the K9c and K9d steels of 36 different heat treatments, described previously. These tests include such immersion treatments as produce disintegration of faulty 18 per cent chromium, 8 per cent nickel alloy in short periods of time, namely, copper sulfate and nitric acid tests. Sheet metal specimens of various heat treatments as well as specimens prepared from $\frac{5}{8}$-in. square rod have been supplied for these tests. It is anticipated that a very informative correlation of the immersion tests will be made with the information to be reported by Subcommittees G on Impact Tests and M on Metallography and Structural Stability, together with magnetic measurements already reported by two laboratories.

Respectfully submitted on behalf of the committee,

L. W. SPRING,
Chairman.

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[1] N. L. Mochel "Thermal Expansion of Metals," Symposium on Effect of Temperature on the Properties of Metals, published jointly by the American Society for Testing Materials and the American Society of Mechanical Engineers (1931).

APPENDIX I

PROGRESS REPORT ON FATIGUE TESTS OF LOW-CARBON STEEL AT ELEVATED TEMPERATURES

By H. F. Moore[1] and N. J. Alleman[2]

Material and Test Specimens.—The material tested was plain carbon steel furnished by the Joint Research Committee (A.S.M.E. and A.S.T.M.) on Effect of Temperature on the Properties of Metals, and was designated by them by the mark *K1*.

The composition of the steel and its preliminary heat treatment were reported to be as follows:

Carbon, per cent	0.17
Manganese, per cent	0.42
Phosphorus, per cent	0.012
Sulfur, per cent	0.035

Normalized by heating 1 hour at 1650 to 1700° F. and cooling in air.

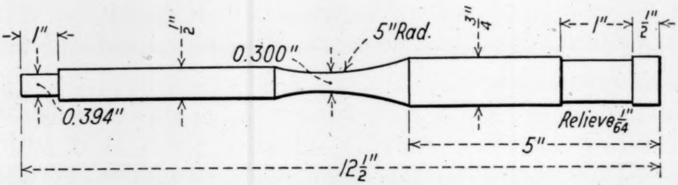

Fig. 1.—Fatigue Test Specimen.

The material was furnished in the shape of bars 1 in. in diameter and 48 in. in length. The bars were furnished with each bar of a pair carrying a letter and number. Most of the bars were in pairs, each bar of the pair carrying the same mark.

The form and dimensions of the fatigue specimen are shown in Fig. 1. Each specimen was marked with the number stamped on the bar when received, and in addition was marked with another number and a letter. The second number denoted the number of inches the specimen was located from one end of the bar from which it was cut, and the letter showed from which one of a pair of bars the specimen was cut. Thus specimen marked F17–36A was from bar A of the pair marked F17 as received, and one end of the specimen was 36 in. from the numbered end of the bar.

Testing Machine for Fatigue Tests.—The testing machine used set up cycles of reversed flexural stress in the specimen tested. The machine is shown in Fig. 2, as used for tests at room temperature. One end of the specimen, *S*, is held rigidly in the vise, *V*, and the other end, which runs in the bearing, *B*, is rotated in a small circle. Sidewise pressure, which can be adjusted by means of a screw, *D*, is brought on the bearing, *B*, through a calibrated indicator spring, *I*. The compression of the spring (and hence the load, the bending moment, and the stress on the specimen) is measured by means of a dial depth gage, *G*, which measures the distance between the ends of the indicator spring. The gage, *G*, is, of coure, removed before starting the machine. Sidewise motion of the bearing, *B*, is prevented by the pivoted arm, *A*, on which it is swung, and excessive displacement of the bearing after the specimen breaks is prevented by the rod, *R*. The rotating head, *C*, which carries the bearing, *B*, the indicator spring, *I*, the pivoted arm, *A*, and the rod, *R*, is driven by a shaft, *H*, a pulley, *P*, and an electric motor. The number of revolutions of the shaft, and hence the number of cycles of stress for the specimen, is measured by a revolution counter, *K*. When the specimen breaks the broken end flies up and hits lever, *Q*, which releases a trigger and opens a mercury switch stopping the motor.

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[1] Professor of Engineering Materials, University of Illinois.

[2] Engineer of Tests, Fatigue of Metals Laboratory, University of Illinois.

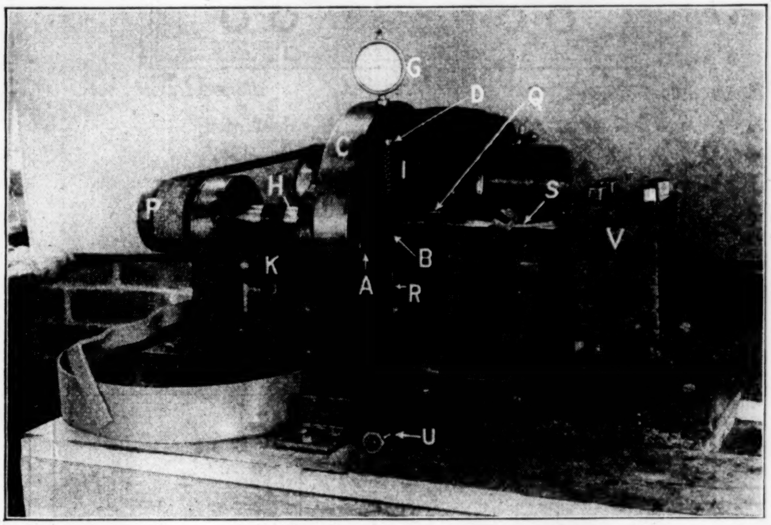

FIG. 2.—Rotating-Spring Testing Machine.

Control of Stress during Fatigue Tests.—At the beginning of a fatigue test the load to produce a given stress was put on the bearing by turning the capstan screw, *D*, and reading the dial gage, *G*. Then the rod *R* was screwed up against arm *A* holding it fast. The dial was then removed and rod *U* inserted thus holding arm *A* securely. After the machine had been started, and the test run a short time, rods *R* and *U* were loosened, and the load read on the dial gage, *G*, and, if necessary, adjusted to its initial value. Then rods *R* and *U* were tightened again, and the test run for another interval of time. Usually during the first 10 hours of a test the load was checked for constancy every hour or oftener, and after that at least once every day.

Furnace for Heating Specimen and Control of Temperature.—The furnace for heating the specimen is shown in Fig. 3 together with the position of the specimen in the furnace. The arrangement of wiring for controlling the temperature of the specimen is a very close copy of the arrangement used by the Westinghouse Research Laboratories, and is shown in the diagram in Fig. 4.

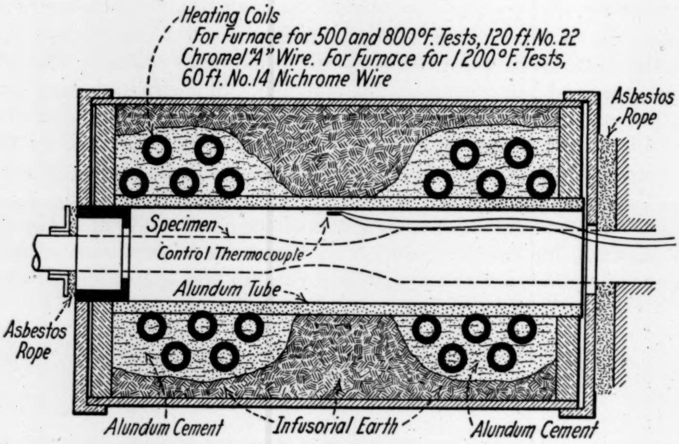
Heating Coils
For Furnace for 500 and 800°F. Tests, 120 ft. No. 22 Chromel "A" Wire. For Furnace for 1200°F. Tests, 60 ft. No. 14 Nichrome Wire
Asbestos Rope
Specimen
Control Thermocouple
Alundum Tube
Asbestos Rope
Alundum Cement
Infusorial Earth
Alundum Cement

FIG. 3.—Furnace for Heating Specimen.

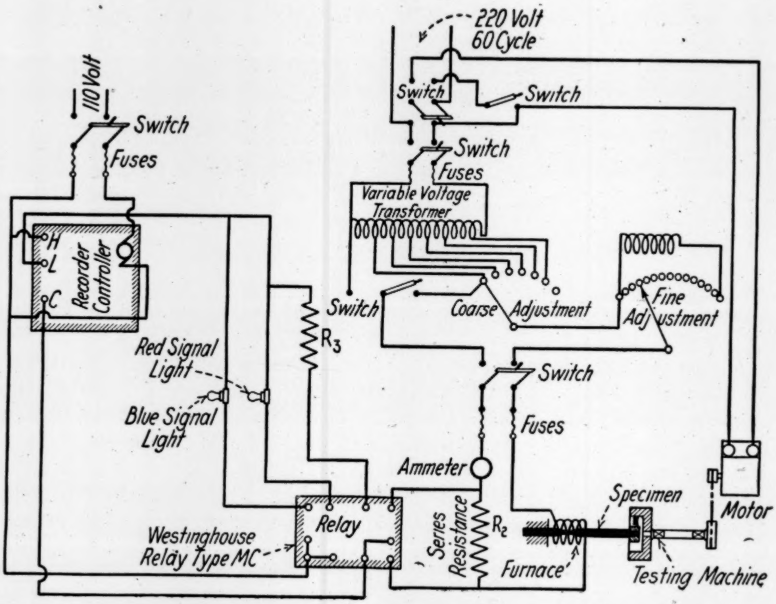
220 Volt 60 Cycle
Switch
Switch
Switch
Fuses
110 Volt
Switch
Fuses
Variable Voltage Transformer
H
L
C
Recorder Controller
Switch
Coarse Adjustment
Fine Adjustment
R_3
Red Signal Light
Blue Signal Light
Switch
Fuses
Ammeter
Specimen
Motor
Relay
Westinghouse Relay Type MC
Series Resistance
R_2
Furnace
Testing Machine

FIG. 4.—Wiring Diagram for Temperature Control Equipment.

Figure 5 shows a testing machine with the furnace around a specimen, temperature recorder controlling resistances and auto transformer. During a test the furnace is surrounded by a composite transite and sheet asbestos case which, in Fig. 5 is shown on the shelf below the testing machine.

Before applying stress to a specimen at the beginning of a run the correct temperature was held for a period of one to two hours. After starting the test the temperature of the specimen was kept constant within a tolerance of ±10° F. This was accomplished by means of a control thermocouple (shown in Fig. 3) held against the inner wall of the alundum tube in the furnace, at the midpoint of the length of the furnace. This couple was connected to a Leeds & Northrup temperature recorder shown in Fig. 5. The control thermocouple was placed against the inner wall of the furnace tube rather than against the heating wire of the furnace because the latter, for temperature of specimen of 1200° F., became too hot to be handled by the recorder-controller. Furthermore, this position is more accessible. The inside wall of the furnace tube responded to

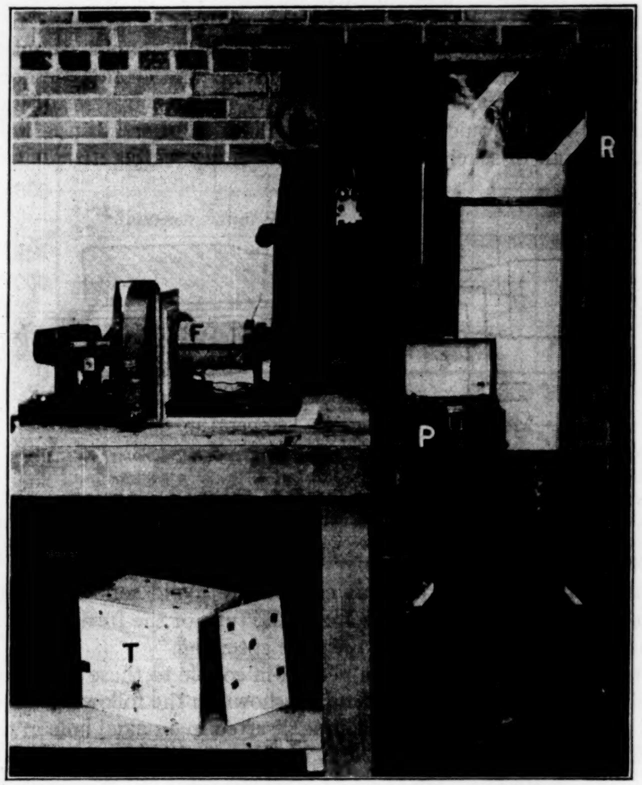

FIG. 5.—Testing Machine and Temperature Control.

R, recorder-controller for control thermocouple
P, potentiometer for thermocouple at surface of specimen
F, furnace
T, transite box, used over furnace during test.

changes of heating current quicker than did the specimen itself, and hence was a better place for the location of the control thermocouple. The readings of temperature of the specimen were found to fluctuate less when the control thermocouple was placed against the inner wall of the furnace tube than when it was placed against the specimen. The reading on the recorder-controller to produce the desired temperature of specimen was determined by trial.

Measurement of Temperature of Specimen.—The significant temperature to be determined is that of the specimen at the surface at the section of maximum stress. The best way to measure surface temperature is, probably, to peen in separately the ends of the two wires constituting the couple, completing the circuit through the metal of the specimen. Unfortunately this method cannot be used in a fatigue test, since the peening in of the wires would introduce "stress raisers" which would make the determination of endurance limit innaccurate. After trials of several methods of measuring temperature it was found that the use of fine wire couples was essential to avoid serious radiation and convection effects from the inner surface of the tube of the furnace to the outer part of a wire thermocouple held against the specimen.

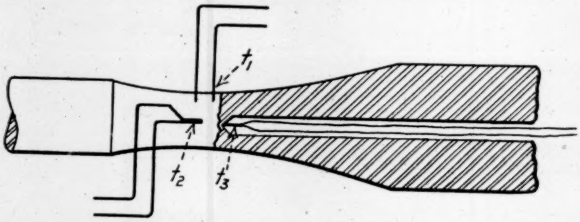

FIG. 6.—Methods of Measuring Temperature of Specimen.

t_1, thermocouple peened into specimen; each wire into separate hole.
t_2, thermocouple held against surface of specimen by No. 30 iron wire.
t_3, thermocouple shoved to bottom of axial hole in specimen.
All thermocouples No. 34 chromel-alumel wire.
All hot junctions at the surface of the specimen are located within 0.05 in. (along the specimen) of the minimum cross-section.

The relation of the readings of a peened-in couple to those of a couple held against the surface of a dummy specimen is shown in the following table, which also shows some results for a thermocouple inserted in an axial hole in the specimen. A diagram of the several methods is shown in Fig. 6.

	TEMPERATURE, DEG. FAHR.		
RUN	THERMOCOUPLE t_1[a]	THERMOCOUPLE t_2[b]	THERMOCOUPLE t_3[c]
No. 1	520	535	495
No. 2	530	550	510
No. 3	755	760	705
No. 4	760	765	720
No. 5	800	800	770
No. 6	1147	1165	...
No. 7	1200	1210	...
No. 8	780	790	...
No. 9	1180	1200	...

---

[a] Wires for thermocouple t_1 peened into separate holes, approximately 0.016 in. in diameter, 0.05 in. deep and 0.05 in. apart.

[b] Thermocouple t_2 held firmly against specimen by two turns of No. 30 iron wire.

[c] Thermocouple t_3, shoved to bottom of axial hole in specimen.

The readings of temperature of the surface of the specimen were taken by means of a Leeds & Northrup portable potentiometer indicator (their catalog No. 8657).

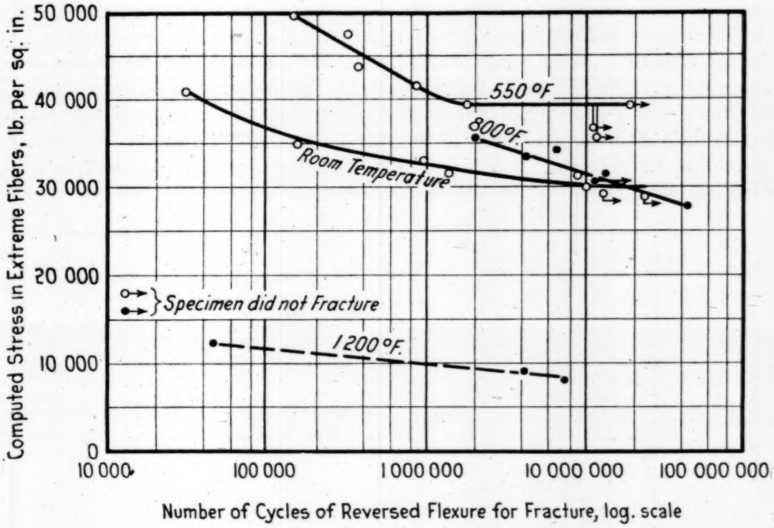

FIG. 7.—*S-N* Diagrams for Tests at Various Temperatures, Tests Run at 2500 r.p.m.

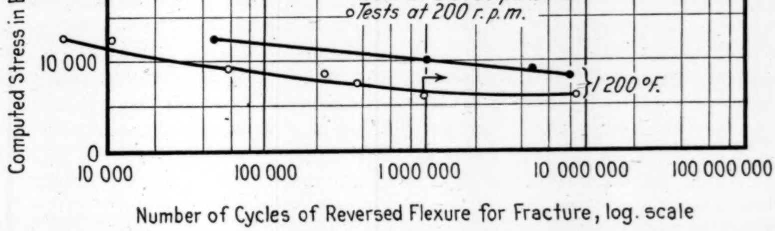

FIG. 8.—*S-N* Diagrams for Tests at Elevated Temperatures and Different Speeds.

Each thermocouple used was calibrated by taking readings at the melting point of samples of pure tin, lead, zinc, and aluminum, furnished by the Chemical Laboratories of the University of Illinois.

Test Data and Results.—The data of the tests are shown in Figs. 7 and 8, if the form of *S-N* diagrams. For the tests at room temperature there is a fairly well-defined endurance limit of 30,000 lb. per sq. in. For the tests at 550° F. there is a well-defined endurance limit of 39,000 lb. per sq. in., a distinct increase above the results at room temperature. For the tests at 800° F. and at 1200° F. run at 2500 r.p.m. no clearly defined endurance limit was obtained although at 800° F. tests were run to 43,000,000 cycles of stress. Tests are still continuing at 1200° F. It is obvious that the endurance limit at these two temperatures is less than 28,000 lb. per sq. in. in the case of the 800° F. tests and less than 8000 lb. per sq. in. in the case of the 1200° F. tests. A comparison of these results with the creep test results reported by J. J. Kanter, and L. W. Spring[1] of the Crane Co., to the Joint Research Committee indicates that the results of the fatigue tests so far seem to be somewhat above the limiting stress for a flow of 1 per cent in 10,000 hours.

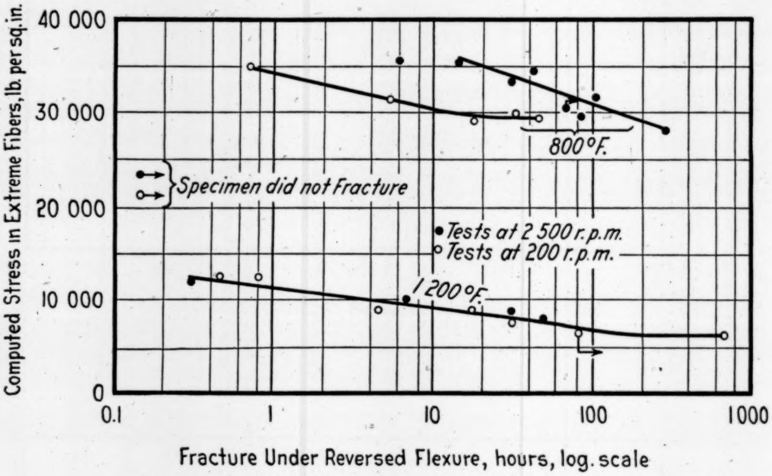

FIG. 9.—Stress-Time Diagrams for Repeated-Stress Tests.

Figure 8 shows a comparison of the tests at two different speeds for temperatures of 800° F. and 1200° F. It is obvious that the *S-N* diagrams for the slower speed lie distinctly below those for the higher, at the higher stresses, but that there is a tendency for the diagrams to approach each other at the lower stresses. In this connection Fig. 9 has been plotted with stress as ordinates and actual hours of time for the fatigue tests as abscissas. It will be noted that on the diagram for 1200° F. there is no marked difference between the results for the tests at 2500 r.p.m. and those for 200 r.p.m. A single stress-time diagram would serve for all the tests made at 1200° F.

It has been shown by a number of independent investigators[2, 3] that at room temperatures the number of cycles of stress is the governing factor in a fatigue test and not the rate of application of stress. The experimental data on which this conclusion is based cover rates of loading ranging from 200 cycles a minute to 5000 cycles a minute. These tests herein reported seem to indicate that for the material tested at temperatures as high as 1200° F., the time under test seems to be the controlling factor rather than the number of cycles. This fact together with the very low "flow limits" reported by Kanter and Spring suggest that above temperatures somewhere in the vicinity of (say) 1000° F. the creep limit becomes the significant strength criterion for this metal rather than the fatigue limit, even for service under repeated stress.

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[1] J. J. Kanter and L. W. Spring, "Some Long-Time Tension Tests of Steels of Elevated Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 110 (1930).

[2] H. F. Moore and J. B. Kommers, "An Investigation of the Fatigue of Metals," *Bulletin No. 124*, University of Illinois, Engineering Experiment Station, p. 27 (1921).

[3] H. F. Moore and T. M. Jasper, "An Investigation of the Fatigue of Metals," *Bulletin No. 136*, University of Illinois, Engineering Experiment Station, p. 58 (1922).

Acknowledgment.—The tests were made under the general guidance of the Joint Research Committee of the A.S.M.E. and A.S.T.M. on Effect of Temperature on the Properties of Metals and were financed from funds collected by the committee, as summarized in the 1931 annual report. The tests were all made in the Fatigue of Metals Laboratory of the University of Illinois. Acknowledgment is made of the assistance of Mr. C. W. Dollins, student test assistant.

APPENDIX II

APPARATUS FOR LOW-TEMPERATURE ENDURANCE TESTING

By H. W. Russell[1] and W. A. Welcker, Jr.[1]

Low-temperature endurance testing is reported to be in progress in a few laboratories in this country. While details of the methods in use have not been published, it is probable that the machines are being entirely enclosed in mechanically refrigerated chambers. It is believed that the apparatus which have been developed for securing the data reported in the paper by the senior author[2] as a part of the Symposium on Effect of Temperature on Metals offers certain advantages, among which are moderate cost of construction and operation.

In the design of apparatus for low-temperature endurance testing, attention must be given to the following points:

1. The choice of the temperature at which the test is to be made may be a compromise between what is desired and what can be secured. A temperature of −40° C., which is in the region of the lowest naturally occurring temperature, was chosen for the work. This temperature is difficult and expensive to secure by mechanical refrigeration. Solid CO_2, now quite generally available, has a temperature of about −79° C. The apparatus was designed to utilize this as the cooling agent.
2. The temperature must remain constant over long periods of time (up to 20 days) with the minimum of attention. This calls for automatic temperature control.
3. The temperature of the specimen must be known. Heat generated by the testing machine and by internal work in the specimen, will tend to warm the specimen above the temperature of the surroundings. Materials such as the alloy, 18 per cent chromium, 8 per cent nickel, which develop considerable heat on repeated stressing may be many degrees warmer than the surroundings.
4. Special lubricant must be provided for the bearings of the testing machine. It must have a very low pour point, and it must minimize the generation of heat.
5. Isolation of the driving motor of the testing machine is important. Ease of changing specimens and of observation of the revolution counter are desirable.

Cooling Chamber:

The cooling chamber was designed for use with an R. R. Moore endurance testing machine operating at 1750 r.p.m. It is shown in Fig. 1. A wooden box fits over the endurance machine between the driving motor, *M*, and the revolution counter, *F*, and rests on a board passing under the base of the machine. Slots at the motor and counter ends permit the entire box to be removed for

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[1] Battelle Memorial Institute.

[2] H. W. Russell, "Effect of Low Temperatures on Metals and Alloys" (see Tables IX to XII and Figs. 1 to 8), appearing in Symposium on Effect of Temperature on the Properties of Metals, published jointly by the American Society for Testing Materials and the American Society of Mechanical Engineers (1931).

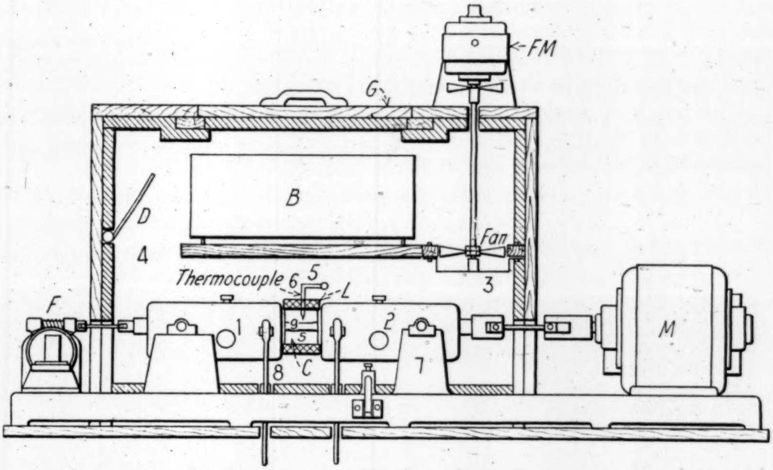
FM
G
B
D
4
Fan
Thermocouple
6
5
L
3
F
1
2
9
5
C
8
7
M

FIG. 1.—Cooling Chamber for Low-Temperature Endurance Testing. (Numbers show location of thermocouples in temperature distribution test.)

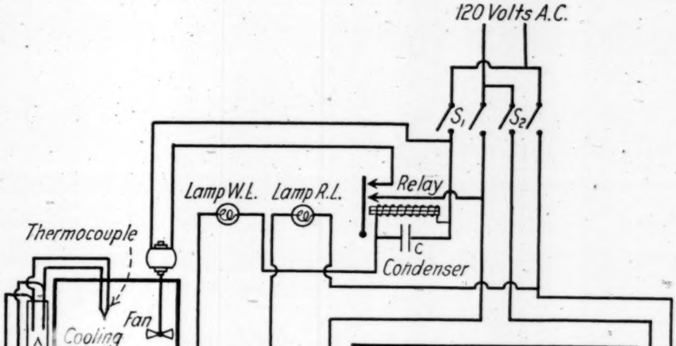
120 Volts A.C.
S_1
S_2
Relay
Lamp W.L.
Lamp R.L.
C
Condenser
Thermocouple
Fan
Cooling Chamber
Ice
L. & N. Recorder Controller
M
T.C.
H
C
L
Potentiometer Indicator

FIG. 2.—Wiring Diagram of Temperature Controlling Mechanism.

changing specimens. A door, *G*, at the top provides access to the inside of the chamber for inspection and for adding the refrigerant. The inside of the box is lined with 2 in. of cork-board sealed with asphalt. This provides an insulation not readily affected by moisture. A pad of hair felt, cut and slotted to conform, covers the metal parts of the base inside of the box.

The box is divided into an upper and lower chamber by a movable wooden partition. In the upper chamber, a movable wire basket, *B*, raised by legs ½ in. in length, provides a receptacle for the solid carbon dioxide which is used as a cooling agent. At one end of the partition is a fan in a circular hole. This fan is driven by a shaft from the motor, *FM*, mounted on the top of the box. At the other end of the partition is an opening controlled by a movable damper, *D*.

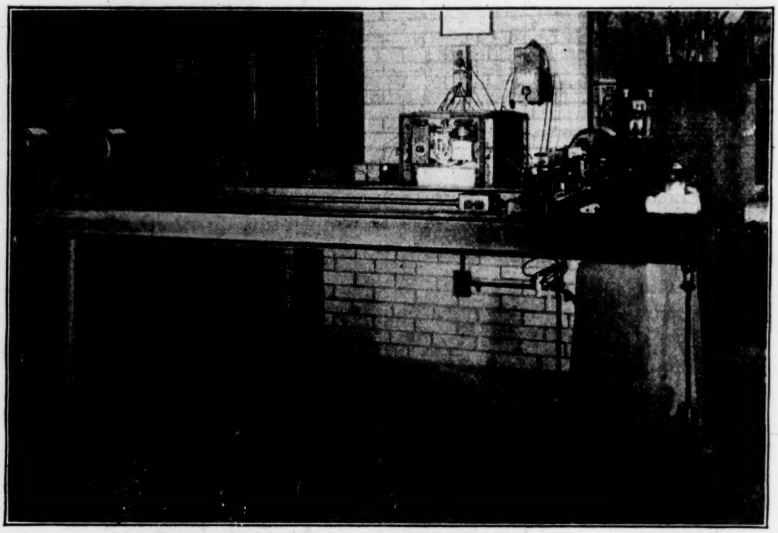

FIG. 3.—Apparatus for Room and Low-Temperature Endurance Testing.

Around the test specimen, *S*, and carried by the ends of the bearings of the endurance testing machine, is a loose spiral of annealed copper wire. Around this is wrapped a layer of cotton wool, *L*, forming an inner chamber, *C*, of about 2 in. in diameter. Into this chamber, the thermocouple is placed just above the specimen. The wires pass horizontally to the outside of the box, and to a vacuum bottle containing ice, fastened to the box. The wires inside of the box are wrapped with cotton wool to reduce the effects of thermal conduction.

Temperature Control Equipment:

Figure 2 shows the wiring diagram of the temperature controlling mechanism. The iron-constantan thermocouple in the inner chamber has its "cold" or reference junction in melting ice. From binding posts at this junction, copper wires lead to a Leeds & Northrup potentiometer recorder-controller, calibrated in millivolts and without "cold" junction compensation. This provides a convenient and permanent record of the inner chamber temperature. A potentiometer indicator provides for occasional checks and more precise readings of the temperature. The thermocouple was calibrated at the mercury melting point and the CO_2 sublimation point.

On closing switch S_1 (Fig. 2) the fan is set into operation, cooling the lower chamber. Switch S_2 starts the motor of the recorder-controller. When the temperature of the inner chamber becomes lower than −40° C., the "high" contact of the controller is opened, extinguishing the lamp, *WL*, and opening the relay. A condenser, *C*, around the relay is necessary to prevent burning the controller contacts. The opening of the relay stops the fan, permitting the chamber to warm up. If, for any reason, the chamber becomes much too warm, about −30° C., the low contact is closed, lighting a red lamp, *RL*, which warns the operator. Figure 3 shows the equipment in use.

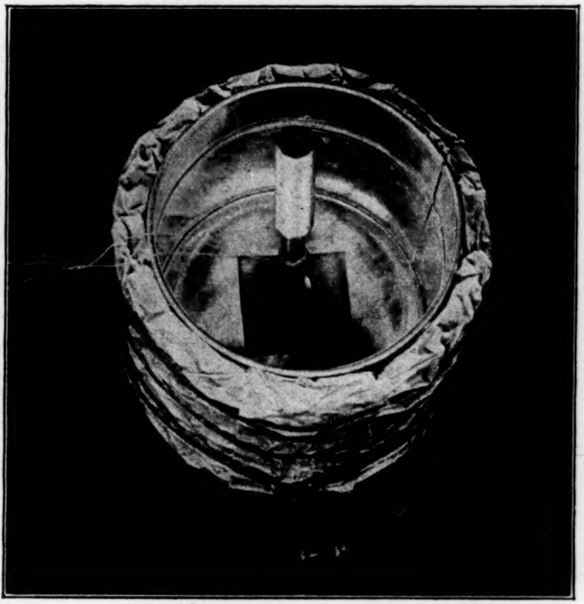

FIG. 4.—Cooling Bath for Low-Temperature Tension Tests, Showing Specimen in Place.

Lubrication:

As the bearings of the endurance machine are cooled to −40° C., a special oil is necessary for their proper lubrication. As no special oil recommended for use could be found, it was necessary to select and prepare such an oil. The viscosity of various oils and mixtures of oils was measured at −40° C. A 50-50 mixture of light transformer oil and paraffin-free kerosine was found to have a suitable viscosity. This oil has proved satisfactory in the low-temperature endurance machine. Later it was found that kerosine alone served better, giving less heating in the bearings. The machine should not be run, however, with kerosine lubrication until the bearings have cooled sufficiently. The 50–50 mixture is excellent for room temperature.

Operation:

With the specimen in position in the endurance machine, the basket was filled with solid CO_2 and the fan started until the temperature of the inner chamber was that for which the controller was set, that is, a temperature of about −38° C. The motor of the endurance machine was then started and the load carefully applied. At intervals of from one to two hours, more solid CO_2 was added. The machine was kept in operation continuously, the watchman adding solid CO_2 as needed at night.

The box was opened from the top daily to inspect the oil level in the bearings, to lubricate the lower fan bearing, and to remove the frost such as prevented the ready circulation of air. At these times the run was continuous, the temperature of the sample increasing to about −30° C. for a short time.

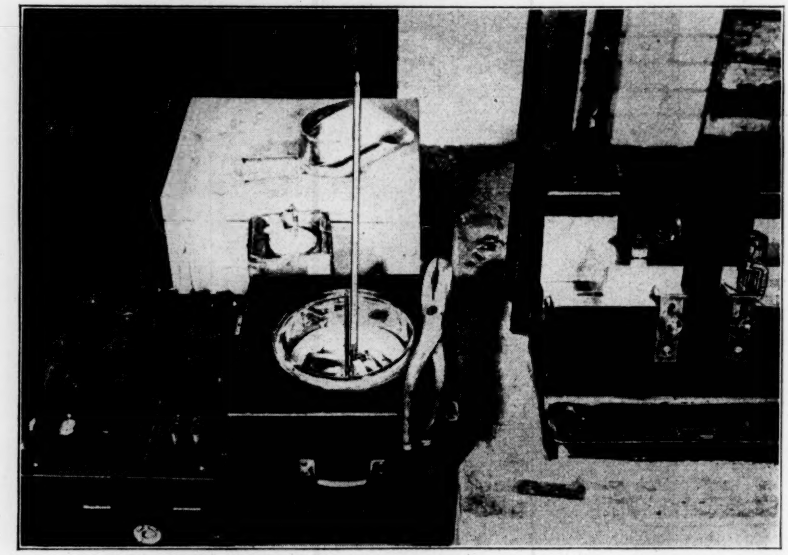

FIG. 5.—Equipment for Low-Temperature Impact Testing.

Temperature Uniformity.—A special temperature study of the temperatures at various places within the chamber was made. In addition to the thermocouple on the controller, nine other thermocouples were distributed about the specimen, as shown in Fig. 1, indicated by numbers 1 to 9. Thermocouple No. 9 was in the inner specimen chamber and could be pulled into contact with the specimen.

The specimen was of 18-per-cent chromium, 8-per-cent nickel alloy which shows a large internal heating effect. The bearing containing thermocouple No. 1 was not in as good condition as for most of the endurance tests.

The results of an extensive series of temperature measurements showed the controlling thermocouple to vary by about 1° C. on either side of −40° C.; but the temperature of the specimen, as measured by stopping the specimen and pulling thermocouple No. 9 into contact, was about −35° C. This difference in temperature represents about the maximum departure from −40° C.

which should be expected during a run, except in the case of highly loaded specimens of 18-per-cent chromium and 8-per-cent nickel alloy. The temperatures of specimens of other materials should be much nearer −40° C. throughout the run.

Bearing No. 2 ran at a temperature slightly below −40° C. Bearing No. 1, which was in poor condition, ran at about −28° C. Thermocouples Nos. 3 and 4 in the air stream showed about −55° C., but varied considerably as the fan started and stopped. Thermocouple No. 5 outside the specimen chamber indicated about −46° C., but varied also. Thermocouple No. 6 on the chamber wall indicated less than −50° C., showing no great heat loss at this point, but thermocouple No. 7 on the metal support indicated about −22° C., and thermocouple No. 8 about −30° C., showing large heat losses through the metal base.

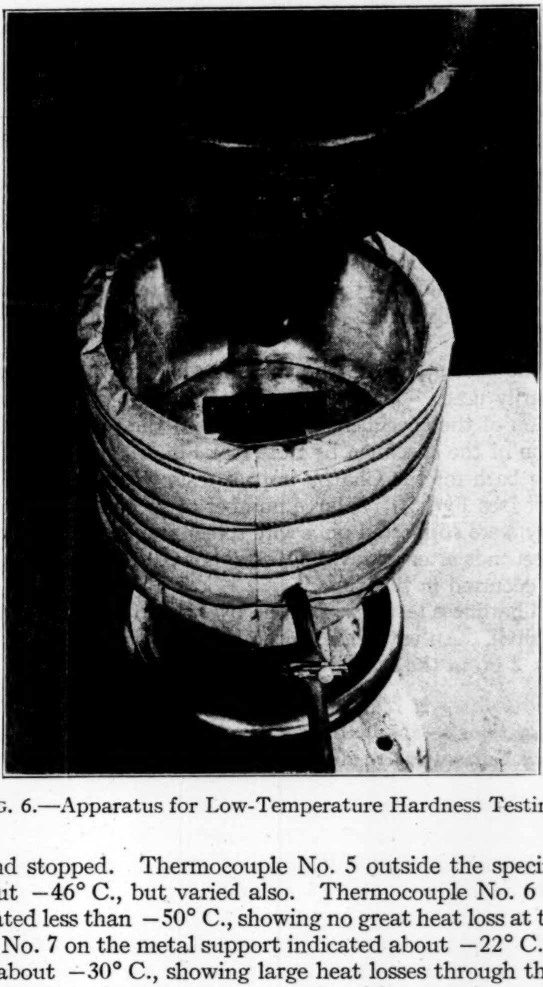

FIG. 6.—Apparatus for Low-Temperature Hardness Testing.

Considering that these tests were made with a specimen of 18-per-cent chromium and 8-per-cent nickel alloy and with one bearing in bad condition, they indicate that the probable limits of temperature variations of a low-temperature endurance specimen are −35° C., to −42° C. These are outer limits, which are only exceeded for a short time when the chamber is opened for lubricating, at which time the temperature may vary and rise to −30° C. for a short time.

Cost of Operation:

Endurance testing even at room temperature is somewhat expensive. A large number of comparatively expensive specimens must be used and the tests extend over a long period of time. The increased cost of operation at low temperature is largely that of the solid carbon dioxide used as a refrigerant. The consumption of solid carbon dioxide depends, of course, upon the temperature of the room and upon the amount of heat generated by the bearings and the specimen. Including loss in storage and shipment, 80 to 120 lb. of solid CO_2 were used per day. A rough estimate of the cost would be $5 a day for refrigeration.

Tensile Strength, Impact and Hardness Tests:

As an aid in the correlation of the results obtained by the endurance testing, low-temperature tests of tensile strength, Charpy impact, and Brinell hardness were made. These tests were made by methods closely analogous to those of previous workers but justify some mention. All tests were made with the use of acetone and solid CO_2 baths and since the tests were of short duration, the temperature could be adjusted by the careful addition of powdered solid CO_2.

In the tensile strength tests, the specimen had a longer threaded portion than is customarily used. This permitted better temperature uniformity over the tested portion of the specimen, and permitted the fastening of the bath to the lower portion of the specimen by nuts (see Fig. 4).

The cooling bath for the Charpy impact tests was a special Dewar vessel, 6 in. in diameter (see Fig. 5). A large number of specimens could be cooled at one time. They were supported on a wire screen, removed with wooden tongs, and tested five seconds after removal. Tests showed that no appreciable change of temperature occurred in this time.

The Brinell hardness testing was done by supporting the metal bath vessel from a special anvil. An extension to the ball holder permitted the ball to be immersed about 2 in. in the bath during the test (see Fig. 6).

APPENDIX III

NEW CREEP TESTING APPARATUS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BY F. H. NORTON[1] AND J. B. ROMER[2]

For several years the creep resistance of steels has been under investigation at the Massachusetts Institute of Technology. This work has been carried out with the equipment described in a previous publication.[3] The equipment consists of three units, each having a single furnace holding six specimens; a total of eighteen specimens can thus be simultaneously under test.

In order to expand this investigation, there has recently been installed, at the Massachusetts Institute of Technology, fifteen new units for the measurement of the long-time creep of steel. As these units were designed with the knowledge gained by several years of experience in long-time creep tests, it was thought that a description of them would be of interest.

Figure 1 gives a general view of the apparatus as set up in the laboratory, together with the original testing equipment. The new equipment differs from the old in having a heavier construction, which makes it possible to use standard 0.505-in. diameter test specimens, even at the lowest temperatures. It was also thought desirable to use a separate heating furnace for each specimen in order to make it possible to replace one specimen without disturbing the others in that set.

The lever system is of very simple construction, and uses a 20 to 1 ratio with 25-lb. weights on the scale pan. Fractions of 25 lb. are obtained by placing the weight at the proper position on the beam.

The frames of the apparatus are of heavy welded steel to give a rigid construction. The heavy base plate is set directly on the concrete floor.

The test specimens are the standard 0.505-in. diameter specimens with 2-in. gage lengths and are screwed into austenitic steel holders, as clearly shown in Fig. 2. The temperature of the specimen is measured by a thermocouple passing through the center of the upper holder, and riveted into a hole in the end of the test specimen at the level of the upper fillet. Each test specimen has four platinum beads welded on to the fillets, which are marked with a fine diamond point to serve as references in measuring the elongation.

The furnaces are wound on austenitic steel tubes with nichrome wire over mica insulation. The winding is so adjusted as to give, as nearly as possible, a uniform temperature over the length of the specimen. It is possible to adjust the winding to give a practically uniform temperature for one temperature of the specimen. However, this temperature distribution will not be the same with different specimen temperatures, so the best possible compromise was made. The resulting temperatures over the specimen do not vary from the mean by more than ± 10° F.

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[1] Babcock & Wilcox Research Fellow, Massachusetts Institute of Technology, Cambridge, Mass.

[2] Chief Chemist and Metallurgist, Babcock & Wilcox Co., Bayonne, N. J.

[3] F. H. Norton, "Creep of Steel at High Temperature," McGraw-Hill Book Co. Inc., New York City.

The elongation of the specimen itself is measured by the two telescopes mounted in an invar block set on a post, as shown in Fig. 3. The same pair of telescopes is used for all the furnaces. The specimen is so adjusted that the reference lines on the platinum beads are in silhouette, as viewed through the sight holes in the walls of the furnace. The background is evenly illuminated by a special lamp. Measurements are taken on both the left and right sides of the specimens to eliminate any error due to uneven extensions. The magnification of the telescopes is ×40, but considerably higher powers could be used, except for the fact that vibrations make the present magnification as high as convenient. In future work of this kind, it would be desirable to have the apparatus set on a vibration-free foundation.

The temperatures of the furnaces are controlled by rheostats mounted behind each furnace and each bank of five furnaces is controlled by a potentiometer controller and a relay which cuts in and out a small series resistance. Only a part of the current is switched off or on; by this means a more constant temperature is obtained. Recording potentiometers give a record of the temperature of each specimen under test, as shown in Fig. 1. The cold junctions of the thermocouples are kept in an ice bottle at all times.

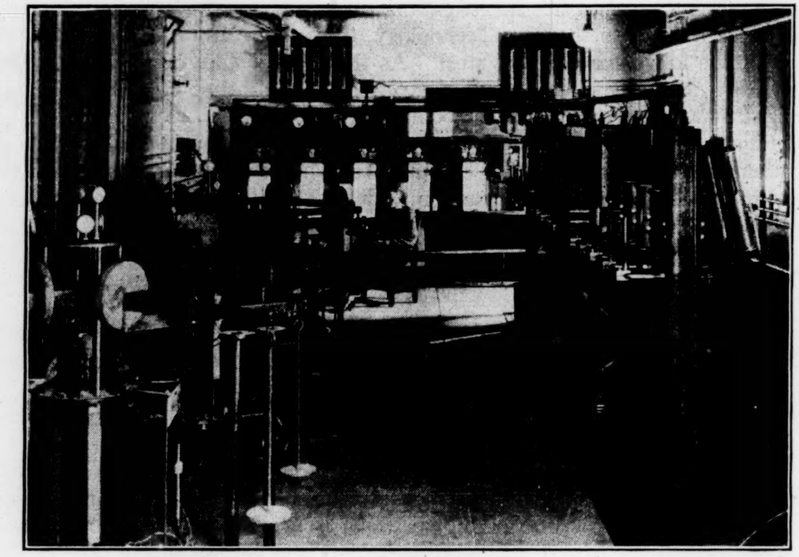


FIG. 1.—General View of Creep Test Apparatus.

The precision of temperature regulation is usually within ± 5° F., or as close as the commercial temperature measuring equipment can be relied upon. The measurement of extensions can be read to ± 0.0001 in. and still greater precision could be obtained if the foundations were more free from vibration.

It will be noted that this new testing apparatus differs from the old, in that, measurements are made directly on the specimen itself, and therefore, no errors are introduced by variation in room temperature, or variation in length of the holders.

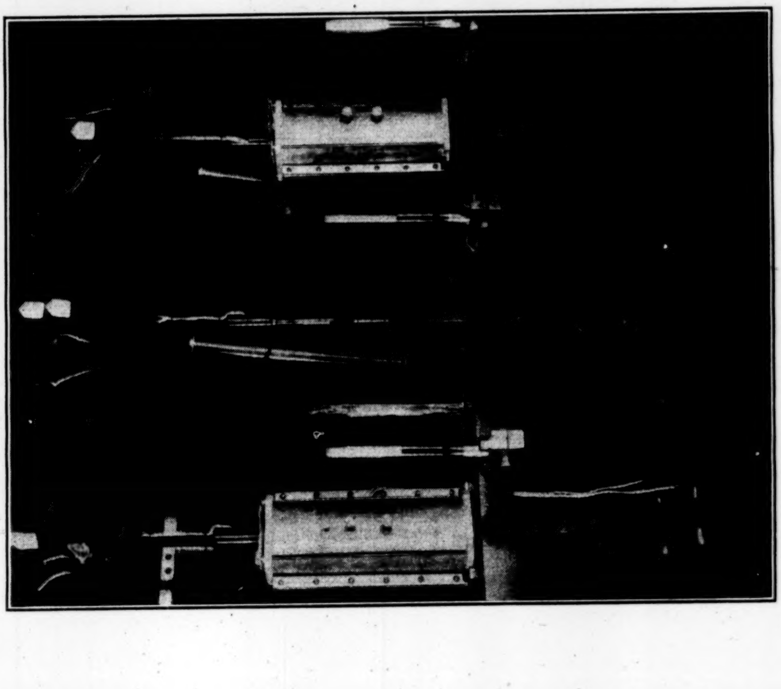


FIG. 2.—View Showing Test Specimen with Furnace Removed.

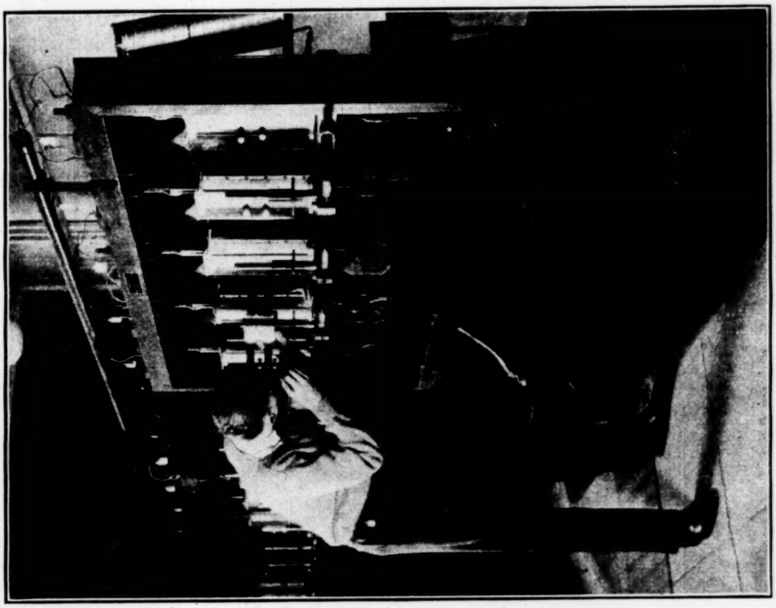


FIG. 3.—View Showing Telescope Attached for Measuring Elongation.

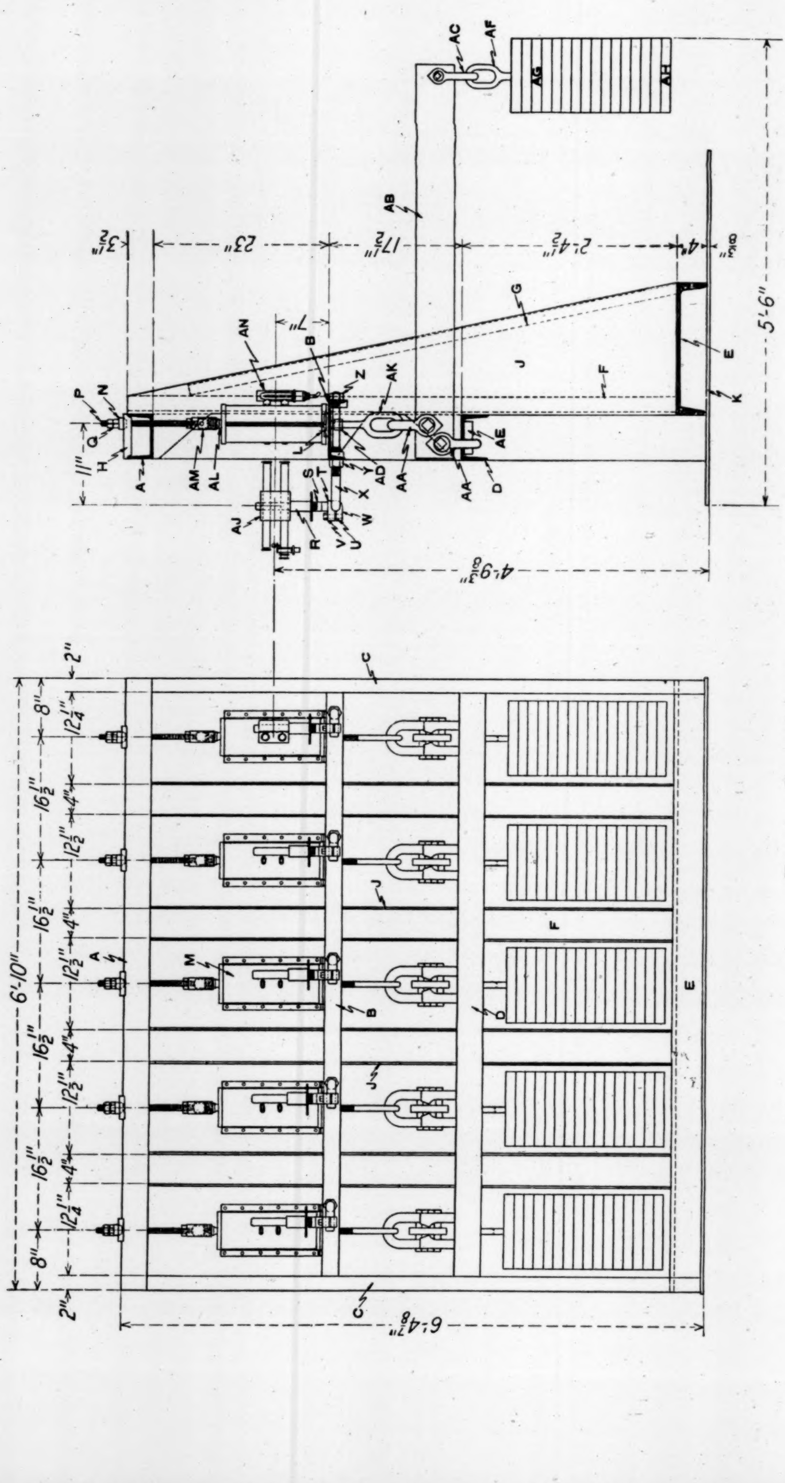
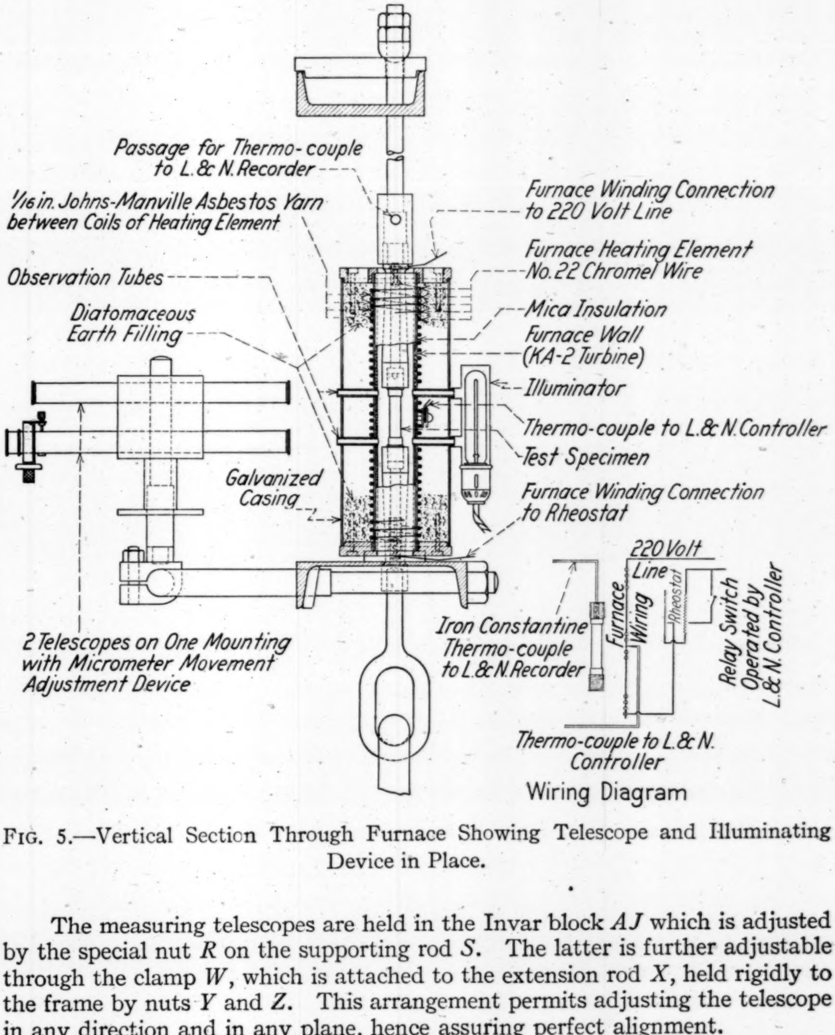

AC
AF
AG
AH
AB
3½"
23"
17½"
2'-4½"
4"
⅜"
5'-6"
G
J
F
E
K
7"
AN
B
Z
AK
P
N
Q
H
11"
A
AM
AL
L
S
T
X
Y
AD
AA
AA
AE
D
AJ
R
V
U
W
4'-9⅜"
2"
C
6'-10"
8"
12¼"
16½"
4"
12½"
M
A
J
F
B
D
E
C
2"
8"
6'-4⅞"

FIG. 4.—General Arrangement of Apparatus.

Figure 4 shows the general arrangement of the apparatus. The frame consists of channels *A* to *G* and plates *H* to *K*. As previously stated, these are joined together by welding. The test specimen within the furnace is supported by the special holders *AL* and *AM* through stud *P* and nuts *N* and *Q*. The load, *AG*, is applied through the lever *AB* to the eyebolt *AK* and thence to the special holder *AD* which connects with the lower end of the test specimen.



Passage for Thermo-couple to L.& N. Recorder
1/16 in. Johns-Manville Asbestos Yarn between Coils of Heating Element
Observation Tubes
Diatomaceous Earth Filling
Galvanized Casing
2 Telescopes on One Mounting with Micrometer Movement Adjustment Device
Furnace Winding Connection to 220 Volt Line
Furnace Heating Element No. 22 Chromel Wire
Mica Insulation
Furnace Wall (KA-2 Turbine)
Illuminator
Thermo-couple to L.& N. Controller
Test Specimen
Furnace Winding Connection to Rheostat
220 Volt Line
Furnace Wiring
Rheostat
Relay Switch Operated by L.& N. Controller
Iron Constantine Thermo-couple to L.& N. Recorder
Thermo-couple to L.& N. Controller
Wiring Diagram

FIG. 5.—Vertical Section Through Furnace Showing Telescope and Illuminating Device in Place.

The measuring telescopes are held in the Invar block *AJ* which is adjusted by the special nut *R* on the supporting rod *S*. The latter is further adjustable through the clamp *W*, which is attached to the extension rod *X*, held rigidly to the frame by nuts *Y* and *Z*. This arrangement permits adjusting the telescope in any direction and in any plane, hence assuring perfect alignment.

The furnace *M* is held in place by the small stud *L*. Whenever operating at low temperatures, illumination is secured by means of the small special lamp, *AN*, shown at the back of the furnace.

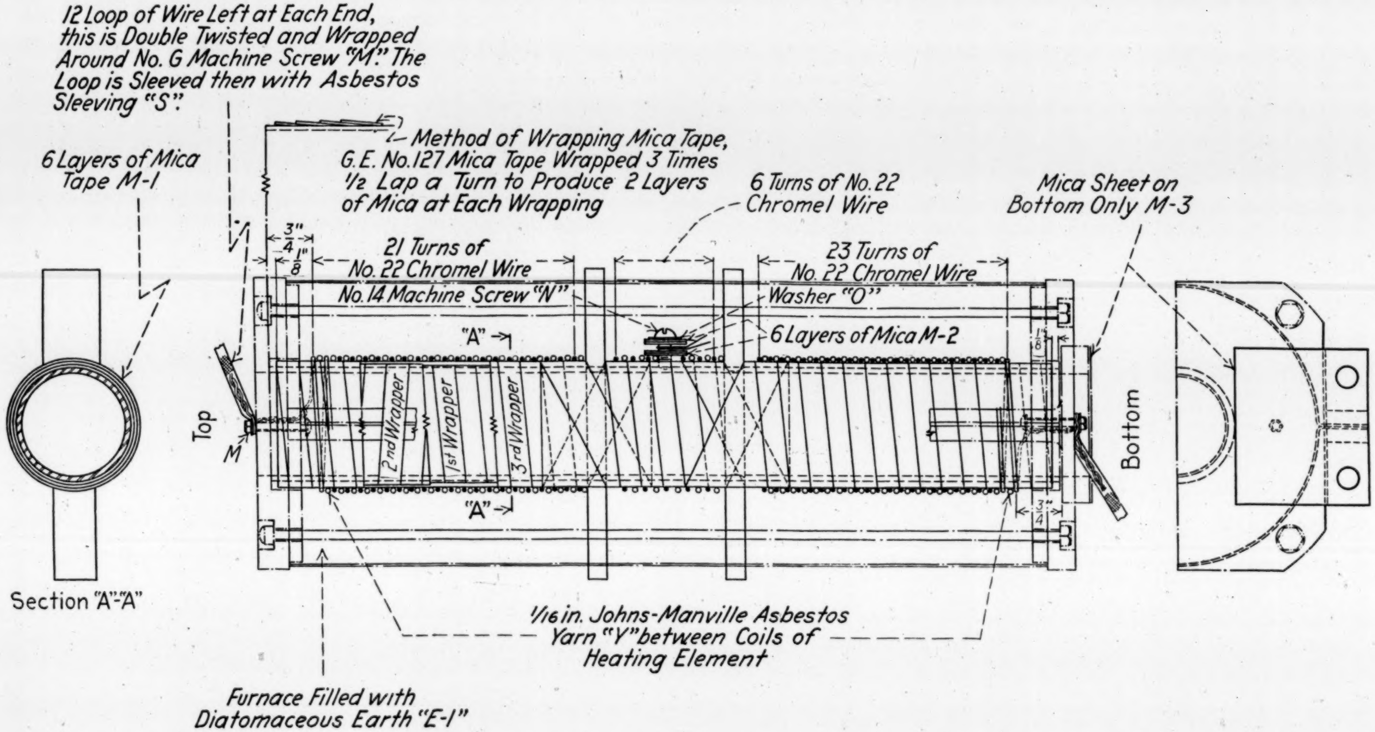

12 Loop of Wire Left at Each End, this is Double Twisted and Wrapped Around No. G Machine Screw "M." The Loop is Sleeved then with Asbestos Sleeving "S".
6 Layers of Mica Tape M-1
Method of Wrapping Mica Tape, G.E. No.127 Mica Tape Wrapped 3 Times 1/2 Lap a Turn to Produce 2 Layers of Mica at Each Wrapping
6 Turns of No. 22 Chromel Wire
Mica Sheet on Bottom Only M-3
3"/4
1"/8
21 Turns of No. 22 Chromel Wire
23 Turns of No. 22 Chromel Wire
No. 14 Machine Screw "N"
Washer "O"
6 Layers of Mica M-2
"A"
2nd Wrapper
1st Wrapper
3rd Wrapper
Top
M
Bottom
1"/8
3"/4
Section "A"-"A"
1/16 in. Johns-Manville Asbestos Yarn "Y" between Coils of Heating Element
Furnace Filled with Diatomaceous Earth "E-1"

FIG. 6.—General Plan of Winding Furnace Tube.

Figure 5 is a vertical section through the furnace with the measuring telescope and illuminating device in place. This also shows the method of installing thermocouples and the wiring diagram.

Figure 6 shows the general plan of winding the furnace tube, the latter is made of seamless austenitic steel tubing.

This apparatus has not been in use for a sufficient length of time for the accumulation of any appreciable amount of data. However, sufficient work has been completed to indicate that the apparatus is fulfilling all expectations, permitting change of one specimen without shutting down the other furnaces, and in general, giving excellent service.

Five additional units have been installed at the Bayonne Laboratory in order to facilitate a study of certain phases of creep that have to do with the application of the data obtained and also to study certain aspects of the metallurgy of creep.

REPORT OF RESEARCH COMMITTEE ON YIELD POINT OF STRUCTURAL STEEL

In addition to the data of test series Nos. 261, 271 and 282, on the effect of speed on tension tests,[1] the committee during 1930 made a study of the relationship between the rate of strain in wedge-gripped specimens and the speed of movable head of the testing machine in 120 tests of series No. 291. The information from these tests forms the basis of the present report.

MATERIAL

The mill test data for the steel used in these tests, series No. 291, is as follows:

DATA FROM MILL TESTS, SERIES NO. 291

	¾-IN. ROUND BAR	⅜ BY 1-IN.	⅜ BY 2½-IN.	1 BY 1-IN.
CHEMICAL ANALYSIS:				
Carbon	0.16	0.14	0.18	0.21
Manganese	0.39	0.31	0.47	0.35
Phosphorus	0.010	0.011	0.010	0.010
Sulfur	0.034	0.045	0.032	0.029
TENSION TESTS:				
Heat number	36 082	40 124	57 163	32 166
Tensile strength, lb. per sq. in.	57 990	55 130	58 515	58 175
Yield Point, lb. per sq. in.	37 865	38 210	38 025	36 650
Elongation in 8 in., per cent	27.75	30.50	33.25	28.62

Two 24-ft. lengths of each of the sizes of bar shown in the above table were cut into 18-in. lengths. Each of five cooperating laboratories was supplied with three specimens from each of these bars. Material for this series of tests was donated by the Illinois Steel Co. and the specimens were prepared under the direction of Mr. F. S. Crane of that company.

METHOD OF TESTING

The machine and cooperating laboratories are listed in Table I. The actual speeds of the movable head were determined within ± 3 per cent. Specimens were securely gripped so that a free length of 10 in. obtained between grips. In tests on the smaller specimens a load of 4000 lb. was quickly applied, then the speed was reduced to the scheduled amount, the poise set at 5000 lb., and a stop watch was started when the scale beam raised. The poise was then run ahead to 10,000 lb. and the watch stopped when the beam again raised. For the larger specimens the load interval timed was 12,000 to 24,000 lb. Assuming the modulus of elasticity of the steel to be 30,000,000 lb. per sq. in. and the length of specimen undergoing stretch to be 10 in., it follows that:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 105 (1928); Vol. 29, Part I, p. 101 (1929); Vol. 30, Part I, p. 133 (1930).

$$\text{Rate of strain in inches per minute} = \frac{\text{Increment in load}}{50{,}000 \times \text{area} \times \text{elapsed time in seconds}}$$

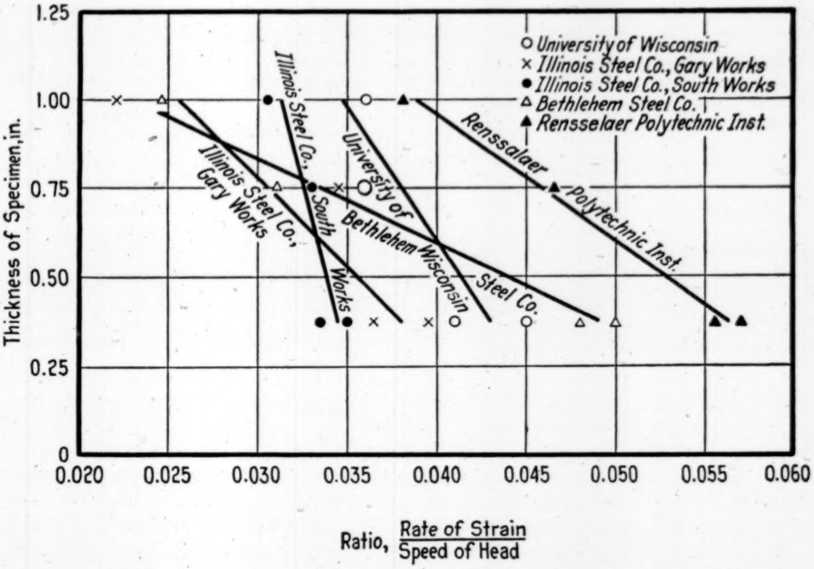

FIG. 1.—Effect of Thickness of Specimen on Ratio of Rate of Strain to Speed of Head.

RESULTS OF TESTS

The speeds used and the average results obtained from each group of three specimens tested are shown in Table I.

It will be noted that in these tests the ratio rate of strain to speed of head ranges from 0.019 to 0.057.

For the different bars the mean ratio was greatest for the 1 by $\frac{3}{8}$-in. bars (0.045) and least for the 1 by 1-in. bars (0.030). The mean ratio of rate of strain to speed of head for the different machines varied from 0.030 to 0.049. It was least for the 200,000-lb. and the 100,000-lb. machines of the Illinois Steel Co. and greatest for the 60,000-lb. machine at Rensselaer Polytechnic Institute.

In Fig. 1 the horizontal dispersion of the points representing a given size of bar shows that the conditions of the grips and jaws of the individual machines affected markedly the ratio rate of strain

TABLE I.—RESULTS OF TESTS TO DETERMINE THE RELATION BETWEEN SPEED OF MOVABLE HEAD AND RATE OF STRAIN OF TEST PIECE—SERIES NO. 291.

Each Value Represents the Average of 3 Specimens.

Laboratory	Machine	Speed of Head, in. per minute	Average Area of Cross-Section, sq. in.	Load at Beginning of Timing, lb.	Load at End of Timing, lb.	Elapsed Time, second	Rate of Strain, in. per minute	Ratio, $\frac{\text{Rate of Strain}}{\text{Speed of Head}}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1 BY $\frac{3}{8}$-IN. SPECIMEN								
University of Wisconsin	Riehle 3-screw, 200,000-lb.	0.184	0.385	5 000	10 000	31.6	0.0082	0.045
		0.64	0.385	5 000	10 000	9.1	0.029	0.045
Illinois Steel Co., Gary Works	100,000-lb.	0.17	0.387	5 000	10 000	40.1	0.0064	0.038
		1.20	0.385	5 000	10 000	5.3	0.049	0.041
Illinois Steel Co., South Works	400,000-lb.	0.125	0.385	5 000	10 000	56.3	0.0046	0.037
	200,000-lb.	0.44	0.385	5 000	10 000	18.1	0.014	0.033
Bethlehem Steel Co., Coatesville Plant	100,000-lb.	0.12	0.384	5 000	10 000	43.8	0.0060	0.050
		0.50	0.384	5 000	10 000	10.4	0.025	0.050
Rensselaer Polytechnic Inst.	60,000-lb.	0.05	0.384	5 000	10 000	9.41	0.0027	0.055
		0.471	0.386	5 000	10 000	10.10	0.0026	0.056
Mean Ratio								0.045
Percentages of variation of average ratios from mean ratio								Minimum 27 Maximum 14 Average 24
$\frac{3}{4}$-IN. ROUND RODS								
University of Wisconsin	Riehle 3-screw, 200,000-lb.	0.184	0.449	5 000	10 000	33.5	0.0066	0.036
		0.64	0.448	5 000	10 000	9.5	0.023	0.036
Illinois Steel Co., Gary Works	100,000-lb.	0.17	0.451	5 000	10 000	41.9	0.0053	0.031
		1.20	0.450	5 000	10 000	4.8	0.0437	0.038
Illinois Steel Co., South Works	400,000-lb.	0.125	0.451	5 000	10 000	60.5	0.0037	0.029
	200,000-lb.	0.44	0.453	5 000	10 000	13.6	0.016	0.037
Bethlehem Steel Co., Coatesville Plant	100,000-lb.	0.12	0.446	5 000	10 000	56.5	0.0040	0.033
		0.50	0.446	5 000	10 000	15.4	0.014	0.029
Rensselaer Polytechnic Inst.	60,000-lb.	0.0469	0.448	5 000	10 000	99.9	0.0022	0.048
		0.459	0.453	5 000	10 000	10.7	0.021	0.045
Mean Ratio								0.036
Percentages of variation of average ratios from mean ratio								Minimum 19 Maximum 33 Average 13
1 BY 1-IN. SPECIMEN								
University of Wisconsin	Riehle 3-screw, 200,000-lb.	0.184	1.014	12 000	24 000	36.3	0.0066	0.036
		0.64	1.013	12 000	24 000	10.4	0.023	0.036
Illinois Steel Co., Gary Works	100,000-lb.	0.17	1.011	12 000	24 000	56.0	0.0042	0.025
		1.20	1.012	12 000	24 000	10.7	0.022	0.019
Illinois Steel Co., South Works	400,000-lb.	0.125	1.013	12 000	24 000	56.1	0.0042	0.034
	200,000-lb.	0.44	1.012	12 000	24 000	19.9	0.012	0.027
Bethlehem Steel Co., Coatesville Plant	100,000-lb.	0.12	1.012	12 000	24 000	75.2	0.0031	0.026
		0.50	1.012	12 000	24 000	20.5	0.0115	0.023
Rensselaer Polytechnic Inst.	60,000-lb.	0.0477	1.015	12 000	24 000	125.8	0.0019	0.039
		0.4361	1.018	12 000	24 000	14.4	0.016	0.037
Mean Ratio								0.030
Percentages of variation of average ratios from mean ratio								Minimum 37 Maximum 30 Average 21

TABLE I—(*Continued*).

Laboratory	Machine	Speed of Head, in. per minute	Average Area of Cross-Section, sq. in.	Load at Beginning of Timing, lb.	Load at End of Timing, lb.	Elapsed Time, second	Rate of Strain, in. per minute	Ratio, $\frac{\text{Rate of Strain}}{\text{Speed of Head}}$
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
				2½ BY ⅜-IN. SPECIMEN				
University of Wisconsin..................	Riehle 3-screw, 200,000-lb...	0.184	0.922	12 000	24 000	35.3	0.0074	0.040
		0.64	0.922	12 000	24 000	9.6	0.027	0.042
Illinois Steel Co., Gary Works.............	100,000-lb...	0.17	0.920	12 000	24 000	42.1	0.0061	0.036
		1.20	0.925	12 000	24 000	5.9	0.044	0.037
Illinois Steel Co., South Works.............	400,000-lb.....	0.125	0.924	12 000	24 000	53.8	0.0048	0.039
	200,000-lb.....	0.44	0.927	12 000	24 000	21.3	0.0122	0.028
Bethlehem Steel Co., Coatesville Plant....	100,000-lb...	0.12	0.919	12 000	24 000	43.7	0.0060	0.050
		0.50	0.923	12 000	24 000	11.6	0.023	0.046
Rensselaer Polytechnic Inst...............	60,000-lb....	0.0439	0.926	12 000	24 000	102.7	0.0025	0.057
		0.4323	0.930	12 000	24 000	10.5	0.025	0.057
Mean Ratio..........	....	....	....	....	....	....	....	0.043
Percentages of variation of average ratios from mean ratio....................................								Minimum 35 Maximum 33 Average 17

to speed of head. Nevertheless, there is evidence in Fig. 1 that this ratio for a given machine is greater for thin than for thick specimens.

The data plainly show that the ratio rate of strain to speed of head is independent of the speed of the movable head. In other words, for a given machine, grips, and size of specimen, it is constant. Undoubtedly, this ratio is affected by deterioration of the grips or the jaws of the machine.

To ascertain the effect of rate of strain of specimen on yield point, the data from the tests on ¾-in. round rods of series No. 261 have been replotted in Fig. 2 using the ratios of series No. 291 to obtain the rates of strain from the recorded speeds of movable head. Since the ratio of rate of strain to speed of head is independent of the speed of head, the curves of Fig. 2 of this report are quite similar to the curves for Fig. 2 of the report made in 1928[1] in which figure the abscissas were speeds of head.

CONCLUSIONS

1. Since the rate of strain bears an important relationship to value of the yield point obtained in tests of structural steel, the speeds of movable head used in testing should be based upon the rate of strain which it is desired to impose on the specimen.

2. A simple and easily applied method for calibrating the speed-rate-of-strain relationship is that employed in these tests.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 109 (1928).

3. For a given machine, condition of grips and size of specimen, the tests indicate that the ratio of rate of strain to speed of head is practically constant for the range of speeds of head between 0.05 and 1.2 in. per minute.

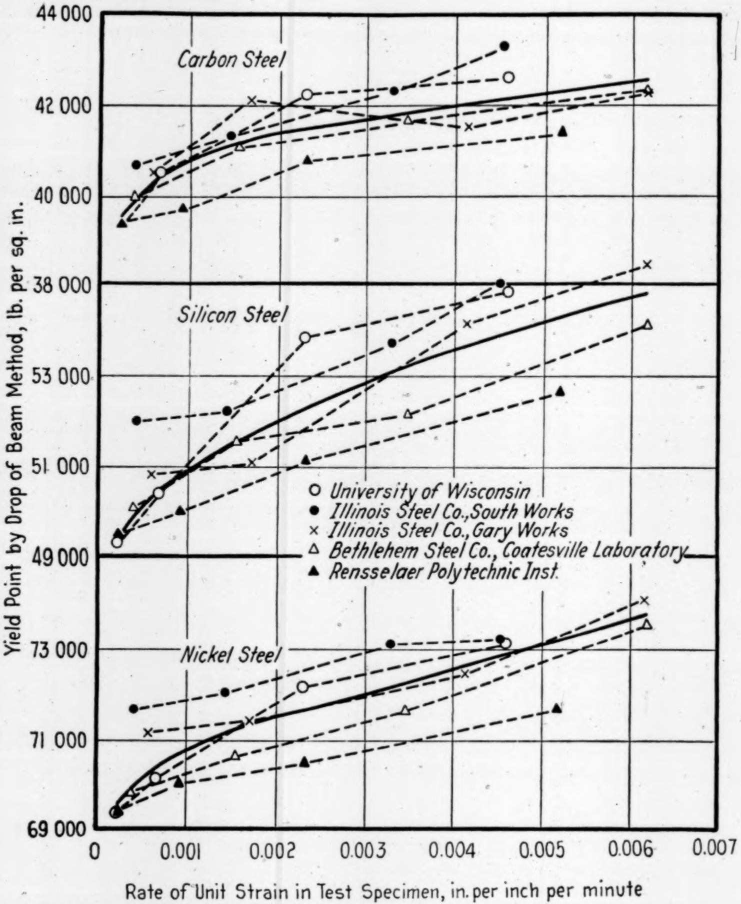

FIG. 2.—Effect of Rate of Strain on Yield Point of Carbon, Silicon and Nickel Steels of Series No. 261.

4. For a given machine and grips the ratio of rate of strain to speed of head appears to vary more or less indirectly with the thickness of the specimen.

This report has been submitted to letter ballot of the committee which consists of 8 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

M. O. WITHEY,
Chairman.

REPORT OF COMMITTEE A-2

ON

WROUGHT IRON

Committee A-2 on Wrought Iron has held one meeting this year at Pittsburgh, Pa., on March 17, 1931. A second meeting will be held prior to the presentation of this report to the Society at which time the report will be reviewed and other matters considered.

Two specifications under the jurisdiction of Committee A-2 have been approved during the year by the American Standards Association as American Tentative Standards. These specifications are as follows:

Standard Specifications for Refined Wrought-Iron Bars (A 41 – 30) (A.S.A. No.: G 12 – 1931); and

Standard Specifications for Wrought-Iron Plates (A 42 – 30) (A.S.A. No.: G 13 – 1931).

The following specifications are being submitted to the American Standards Association under the Proprietary Standards Method of A.S.A. procedure for approval as American Standards:

Standard Specifications for:

- Welded Wrought-Iron Pipe (A 72 – 30);
- Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 30);
- Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 30); and
- Hollow Rolled Staybolt Iron (A 86 – 30).

The resignation of Mr. F. E. Richardson of the Pittsburgh Forge and Iron Co. is announced with regret.

RECOMMENDATIONS AFFECTING STANDARDS

Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 30).[1] —The committee is recommending for immediate adoption the following revision in these standard specifications and accordingly asks for the necessary nine-tenths vote:

Section 13 (a).—Change to read as follows by the addition of the italicized words:

> 13. (*a*) Weight.—The weight of the pipe shall not vary more than 5 per cent *for standard weight and extra strong pipe nor more than 10 per cent for double extra strong pipe* from that specified in Table II.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 430.

Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 30).[1]—The committee is recommending for publication as tentative the following revisions in these standard specifications:

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> Standard Specifications for Staybolt, Engine-Bolt and [Extra-Refined] *Other High-Grade* Wrought-Iron Bars.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> 1. These specifications cover three grades of bar iron:
> Grade A.—Staybolt iron, *round bars only.*
> Grade B.—Engine-bolt iron, *round and hexagon bars only.*
> Grade [C] B_1.—[Extra-refined wrought-iron], *all rectangular* bars.

Section 2.—In the second paragraph change the words "Grades B and C" to read "Grades B and B_1."

Section 6 (a).—Change the physical properties of the third grade of iron in the table following Paragraph (*a*) to read as follows by the addition of the italicized letter and figures and the omission of those in brackets:

		GRADE [C] B_1
Tensile strength, lb. per sq. in.	1¼ sq. in. or under in sectional area	48 000 – [54 000] *53 000*
	Over 1¼ sq. in. in sectional area	[48 000 – 54 000] *47 000 – 53 000*
Yield point, min., lb. per sq. in.	1¼ sq. in. or under in sectional area	0.6 tens. str.
	Over 1¼ sq. in. to 4 sq. in., incl., in sectional area	0.55 tens. str.
	Over 4 sq. in. in sectional area	0.5*0* tens. str.
Elongation in 8 in., min., per cent		25
Reduction of area, min., per cent		[37] *35*

Section 7.—Omit Paragraph (*c*) which reads as follows:

> (*c*) *Grade A.*—For flats of all sizes, the minimum reduction of area shall be 40 per cent.

Reletter Paragraph (*d*) as Paragraph (*c*) and change "Grade C" to read "Grade B_1."

Section 8 (a).—In the second paragraph change "Grade B" to read "Grades B and B_1" and omit the third paragraph which reads as follows:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 435.

Grade C.—Cold-bend tests will be made only on bars having a nominal section area of 4 sq. in. or under, in which case the test specimen shall stand being bent cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to the thickness of the specimen.

Section 8 (*b*).—Change "Grades B and C" to read "Grades B and B_1."

Section 9.—In the third paragraph of this section change "Grades B and C" to read "Grades B and B_1."

Section 10 (*a*).—Change from its present form: namely,

> 10. (*a*) Tension and bend test specimens shall be of the full section of material as rolled, if possible. Otherwise, the specimens shall be machined from the material as rolled; the axis of the specimen shall be located at any point midway between the center and surface of round bars, or midway between the center and edge of flat bars, and shall be parallel to the axis of the bar.

to read as follows:

> 10. (*a*) Tension test specimens for all grades and bend test specimens for Grades A and B shall be of the full section of the material as rolled, if possible; otherwise the specimen shall be machined from the material as rolled. Bend test specimens for Grade B_1 may be reduced by machining to an approximate square, the side of which is equal to the thickness of the original bar. The axes of all specimens shall be parallel to the axis of the bar and shall be located at any point midway between the center and surface of round bars, or midway between the center and edge of flat bars.

Section 12.—In the third paragraph change "Grade C" to read "Grade B_1."

Section 16 (*c*).—In the second paragraph change "Grades B and C" to read "Grades B and B_1."

Standard Definitions of Terms Relating to Wrought-Iron Specifications (*A 81 – 30*)[1].—The committee also recommends the following revision of the definition for double-refined iron for publication as tentative:

Double-Refined Iron.—Change from its present form: namely,

> *Double-Refined Iron.*—Iron rolled from a slab pile or box pile of refined iron bars, all bars running the full length of the pile.

to read as follows:

> *Double-Refined Iron.*—Iron to be classed as double refined, shall be all new wrought iron,[a] which shall be first rolled into muck bars. These bars shall then be twice piled and rerolled. All iron shall be free from steel and from

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 464.

foreign scrap. The manufacturer may use his own mill products of at least equal quality, but only in the first piling. In the final piling all bars shall be of the full length of the pile.

The above recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
PROPOSED REVISIONS IN STANDARDS			
Standard Specifications for Welded Wrought-Iron Pipe (A 72 - 30), immediate adoption	37	0	7
Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 - 30)	43	0	1
Standard Definitions of Terms Relating to Wrought-Iron Specifications (A 81 - 30): Proposed Definition of Double Refined Iron	38	2	4

ACTIVITIES OF SUBCOMMITTEES

In the following, the committee discusses the foregoing recommendations in detail where necessary, as well as other features of its work, in the order of the respective subcommittees responsible for them.

Subcommittee I on Tubes and Pipe (G. H. Woodroffe, chairman).—This subcommittee is recommending an increase in the permissible variation in weight of double-extra-strong pipe in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 - 30), from the present 5 per cent allowance to 10 per cent. In the present state of the art it is not possible to manufacture furnace-welded pipe of double-extra-strong thickness within a weight variation of 5 per cent. The proposed revision brings the weight tolerance into agreement with the Standard Specifications for Welded and Seamless Steel Pipe (A 53 - 30) and other commercial specifications.

Subcommittee III on Staybolt and Engine-Bolt Iron (E. J. Edwards, chairman).—This subcommittee is recommending numerous revisions in the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 - 30). The title of the specifications and the designation of one of the classes of iron covered by the specifications have been changed. Revisions have been made in the physical properties of the third classification which covers only bars of rectangular section.

The subcommittee has also prepared a revision for publication as tentative of the term for double-refined iron appearing in the Standard Definitions of Terms Relating to Wrought-Iron Specifica-

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[a] Wrought Iron is defined as follows in the Standard Definitions of Terms Relating to Wrought-Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

tions (A 81 - 30) in accordance with the instructions of Committee A-2 at the June 1930, meeting.

Subcommittee IV on Plates and Shapes.—This subcommittee has been inactive for a number of years and without a chairman since the resignation of Mr. C. B. Shoemaker, Jr., several years ago. As a result of the present renewed interest in the manufacture and use of wrought-iron plates and small shapes, it seemed desirable for the subcommittee to become active. Accordingly, Mr. James Aston has accepted an appointment as temporary chairman and will reorganize this subcommittee during the current year.

Subcommittee V on Chain Iron and Iron Chain (F. M. Waring, chairman).—This subcommittee has given consideration to a request by the Clinton E. Hobbs Co. to prepare specifications for a strictly hand-forged dredge chain. The unanimous opinion of the subcommittee was that all chain in this country is manufactured by a combination of hand and machine processes and that a specification for a strictly hand-forged chain does not appear to be warranted.

Subcommittee X on Research (J. H. Higgins, chairman).—This subcommittee is at work on a symposium on what consititutes "quality" in wrought iron which is expected to form a part of the report of Committee A-2 for 1932. There is little, if any, published information on this subject, and it is believed that the result of the subcommittees effort will be of interest and value to the industry in general.

This report has been submitted to letter ballot of the committee, which consists of 54 members; 44 members returned their ballots all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. W. Faus,
Chairman.

G. H. Woodroffe,
Secretary.

Editorial Note

The proposed immediate revision of the Standard Specifications for Welded Wrought-Iron Pipe was approved at the annual meeting by a unanimous vote and was subsequently adopted by letter ballot of the Society on September 1, 1931. The standard in its revised form appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 14.

The proposed revisions of the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars and of the definition for double-refined iron in the Standard Definitions of Terms Relating to Wrought-Iron Specifications were accepted for publication as tentative and appear on pages 1043 and 1050, respectively.

REPORT OF SECTIONAL COMMITTEE ON STANDARDIZATION OF DIMENSIONS AND MATERIAL OF WROUGHT-IRON AND WROUGHT-STEEL PIPE AND TUBING

In continuance of the program reported upon last year,[1] the Sectional Committee on Standardization of Wrought-Iron and Wrought-Steel Pipe and Tubing, functioning under the procedure of the American Standards Association, has adopted a basic formula for use in setting up appropriate schedules for pipe wall thicknesses for various pressure-stress relationships. The formula is based on the Barlow formula with modifications to provide for mill tolerance, metal removed in threading, mechanical strength and corrosion. To provide for mill tolerance, the minimum thickness on inspection may be $12\frac{1}{2}$ per cent less than the nominal thickness computed by the formula. This formula is as follows:

For pipe of nominal diameter 1 in. and over .... $P = \frac{1.75S}{D}(t - 0.1)$

where P = the internal pressure in lb. per sq. in., gage;
D = the outside diameter of pipe in inches;
S = the fiber stress in the wall in lb. per sq. in.;
t = the nominal pipe wall thickness in inches.

The above formula has been shown to offer the following advantages in the computation of pipe wall thickness schedules:

1. Eliminates the use of two formulas;
2. Is itself relatively simple;
3. Permits the selection of one value of P/S for each schedule of pipe wall thickness;
4. Involves a minimum of change in existing pipe standards.

During the meeting of the sectional committee held at Detroit in connection with the 1930 spring meeting of the American Society of Mechanical Engineers, the basic formula was adopted unanimously by the members present. On July 28, 1930, this matter was referred to letter ballot of the committee which consists of 40 members. The vote on this ballot resulted in 25 affirmative and 3 negative votes while 12 members failed to return their ballots.

As a result of this ballot, the active formulation of pipe wall-thickness schedules was referred to Subcommittee 2 on Pipe and

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 185 (1930).

Tubing for Low-Temperature Service and Subcommittee 3 on Pipe and Tubing for High-Temperature Service for further consideration. The number of schedules and their corresponding pressure-stress relationships will be selected to suit the needs of the industry. Tentative pipe wall-thickness schedules for one thousand P/S ratios of 25, 40, 50, 70, 105, and 155 have been set up to indicate the application of the formula.

Consideration is being given to the values of stresses allowable in piping for temperatures above 750° F. for use in connection with the basic formula and the cooperation of Subcommittee XXII on Valves, Fittings, Piping and Flanges for High Temperature Service, of Committee A-1 on Steel of the American Society for Testing Materials, has been invited. Subcommittee XXII has referred this request to a subgroup with instructions to report at the June meeting.

Elimination of the $3\frac{1}{2}$-in. nominal pipe size from all A. S. A. flange standards has been under consideration by the Sectional Committee on Pipe Flanges and Fittings. It was recognized by that committee, however, that the cooperation of the pipe trade must be secured before such an elimination could become effective. The members of this sectional committee were invited, therefore, to decide their position in the matter by a letter ballot, the outcome of which indicated that this size should be retained in the thickness schedules corresponding to standard weight and extra strong pipe, but that it should be eliminated from schedules calling for greater thicknesses.

In connection with the work of this sectional committee, Subcommittee IX on Steel Tubing and Pipe, of Committee A-1 on Steel of the American Society for Testing Materials, has prepared tentative specifications for riveted, lock-bar, forge-welded, electric-resistance-welded, and electric-fusion-welded pipe.[1]

A meeting of this sectional committee and its subcommittees will be held in Chicago in June in connection with the annual meeting of the American Society for Testing Materials. It is expected that sufficient progress will have been made at that time by Subcommittees 2 and 3 so that definite schedules of P/S values can be referred to the sectional committee for consideration.

Respectfully submitted on behalf of the sectional committee,

H. H. MORGAN,
Chairman.

SABIN CROCKER,
Secretary.

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[1] See pp. 673 to 693.—ED.

REPORT OF COMMITTEE A-3

ON

CAST IRON

Since the 1930 annual meeting of the Society, Committee A-3 on Cast Iron held one meeting, at Pittsburgh, Pa., on March 17, 1931. A second meeting will be held prior to the presentation of this report to the Society, at which time the report will be reviewed and other matters considered.

Committee A-3 wishes to record its appreciation of the generous help and valued counsel so unselfishly given by Mr. Richard Moldenke during his years of service on this committee. For many years he served as its chairman. In his passing the members of the committee have lost a true friend. Mr. Moldenke's wealth of general knowledge of foundry technology was rivaled by none. This knowledge was at all times freely shared with those with whom he worked. In his many writings he has left us a rich heritage of facts, painstakingly garnered, and couched in language of extraordinary beauty and clarity. His memory and his writings will long remain an inspiration to those who carry on in the field in which he was so long a leader.

The present membership of the committee is 95, of which 36 are classed as producers, 39 as consumers, and 20 as general interest.

RECOMMENDATIONS AFFECTING STANDARDS

Standard Specifications for High-Test Gray-Iron Castings (*A 88–29*).[1]—At the 1930 annual meeting the committee recommended a tentative revision[2] in these standard specifications which increased the requirements on physical properties of high-test gray-iron castings. The committee now recommends that this tentative revision be advanced to standard and incorporated in the standard specifications.

ACTIVITIES OF SUBCOMMITTEES

Committee A-3 at the March meeting voted to discharge Subcommittee VI on General Castings (Robert Job, chairman) and Subcommittee XIII on High-Test Cast Iron (J. W. Bolton, chairman). It was recognized that there is a need for logical classification and development of specifications for cast iron. It was considered that this could best be done by forming a new subcommittee on classification and specification.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 497.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1270 (1930).

Subcommittee VIII on Cast-Iron Soil Pipe and Fittings (E. F. Kelley, chairman).—This subcommittee has been reorganized and renamed during the past year. It is now known as Subcommittee VIII on Cast-Iron Culvert Pipe, with E. F. Kelley as chairman. A number of the former members were dropped and the subcommittee has been strengthened by the addition of a large number of members who are interested in the proposed new scope. The subcommittee is working on specifications for cast-iron culvert pipe.

Subcommittee XIV on Correlation of Test Bar and Casting (R. S. MacPherran, chairman).—This subcommittee has been active during the past year and considerable work has been done by the members of the subcommittee. Some work has been done on the problem of correlation of test bars and selection of the proper type of test bar in gray-iron foundry work. Members of the subcommittee have carried on tests with various sizes of test bars and two reports are included with the subcommittee report, appended hereto, namely, one by Hyman Bornstein on "A Comparison of Various Sizes of Test Bars Representing Cast Irons From Five Foundries" and the other by J. T. MacKenzie entitled "Tests on Cast-Iron Specimens of Various Diameters."

Subcommittee XV on Impact Testing (J. T. MacKenzie, chairman).—This subcommittee has been engaged during the past year in planning and carrying out an extensive investigation on impact testing of cast iron. The subcommittee reports that 23 special sets of test bars were poured at various foundries representing a large number of commercial cast irons. Tension test specimens have been machined from all of these sets and tension tests, including elongation determinations, have been made. The fatigue tests are well under way, while approximately one-half of the transverse tests have been made. Considerable work has been done on the chemical analyses of these irons and these will be completed in a short time.

Various impact tests will be made on the series of test bars with the object of determining a satisfactory impact test for cast iron. The subcommittee wishes to acknowledge the generous cooperation of the U. S. Bureau of Standards in furnishing a man to measure the temperatures of the irons at the various foundries; also, that of the Lynchburg Foundry Co., which company made a very definite contribution in the machining of the test specimens.

The investigation will be completed in time for the 1932 annual meeting of the Society at which time a complete report will be made.

Subcommitte XVI on Heat Treatment of Cast Iron (F. B. Coyle, chairman).—This subcommittee has prepared an extensive digest of the literature on the heat treatment of cast iron. This digest will be studied by the members of the committee with a view to making this information available for publication.

Subcommittee XVIII on Automotive Castings (A. L. Boegehold, chairman).—Subcommittee XVIII has recently been organized and all items in reference to automotive castings, including specifications, will be referred to this subcommittee.

The recommendation appearing in this report has been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
1. ADVANCEMENT TO STANDARD OF TENTATIVE REVISION OF STANDARD			
Standard Specifications for High-Test Gray-Iron Castings (A 88 - 29)	46	0	4

This report has been submitted to letter ballot of the committee, which consists of 95 members; 50 members returned their ballots, of whom 46 have voted affirmatively, and none negatively.

Respectfully submitted on behalf of the committee,

HYMAN BORNSTEIN,
Chairman.

W. H. ROTHER,
Secretary.

EDITORIAL NOTE

The tentative revision of the Standard Specifications for High-Test Gray-Iron Castings was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931. The standard in its revised form appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 19.

REPORT OF SUBCOMMITTEE XIV ON CORRELATION OF TEST BAR AND CASTING

In reporting upon the work of Subcommittee XIV on Correlation of Test Bar and Casting during the past year, it is regretted that more results of the committee members have not been received on the question of test bars of various diameters. Some excellent work on this subject has been done by Mr. Hyman Bornstein and is reported in a paper entitled "A Comparison of Various Sizes of Test Bars Representing Cast Irons From Five Foundries," which appears as Appendix I to this report. This paper is accompanied by curves showing the effect of section on Brinell hardness and tensile strength, as well as photomicrographs of the various sections.

A report has also been received from Mr. J. T. MacKenzie, entitled "Tests on Cast-Iron Specimens of Various Diameters," showing results of chemical, tension, and Brinell hardness tests on various size test bars as cast. This report appears in Appendix II to this report.

The work done on various size test bars by the Wisconsin Grey-Iron Research Group was reported last fall to Mr. Bornstein as chairman of Committee A-3, who has formed a subcommittee on automotive castings. Included among the problems to be considered by this subcommittee will be the question of a test bar thinner in section than the present arbitration bar.

Some progress has been made on the correlation of test bar and castings. The subcommittee wishes to call attention to a paper by J. W. Bolton describing a scheme for correction involving the volume surface relationship which was published in the April 1, 1930, issue of *The Foundry*. This same subject is treated in a paper by Mr. Bolton entitled "Correlation of Cast-Iron Test Bar and Casting by Volume-Surface Ratio" which appears as Appendix III to this report. In the 1929 report[1] of this subcommittee another method of correlation was described in which the correlation was made by means of a formula.

In the course of time, it may be possible to more or less combine these methods of correlation, or even to report them separately and leave the engineer to determine which is more suitable for his purpose.

The subcommittee has been instrumental in obtaining a paper by H. H. Judson on "Shear Test for Cast Iron" to be presented at this annual meeting[2] which discusses the uses of the shear test to supplement the tensile test.

Respectfully submitted on behalf of the subcommittee,

R. S. MacPherran,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 118 (1929).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 304 (1931).

APPENDIX I

A COMPARISON OF VARIOUS SIZES OF TEST BARS REPRESENTING CAST IRONS FROM FIVE FOUNDRIES

By Hyman Bornstein[1]

At the request of Subcommittee XIV on Correlation of Test Bar and Casting, tests have been made on round test bars having diameters of 0.75 in., 1.2 in., 2.0 in., and 3.0 in., cast from the same ladle of iron. The bars were poured vertically in oil-sand cores and a set of bars was prepared at each of five foundries. The irons represented metals used for various farm implement castings and farm tractor castings.

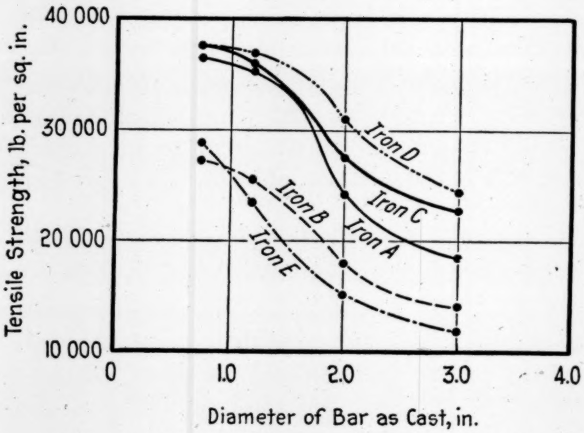

Fig. 1.—Relation Between Tensile Strength and Diameter of Test Bar as Cast.

For iron A, 5 per cent of steel was used in the charge; for iron B, no steel; for iron C, 10 per cent of steel; for iron D, 12 per cent of steel and for iron E, no steel. Iron D is used for tractor castings and the other irons for various farm implement castings. Results of the chemical analyses are shown in Table I.

Transverse tests and Brinell hardness determinations were made on all of the test bars. The average results are shown in Table I. Standard A.S.T.M. tension test bars, 0.8 in. in diameter, were prepared from all the transverse test bars except the 0.75-in. bars and from these, tension test bars 0.505 in. in diameter were prepared. In every case the tension test bars were machined from the center of the broken halves of the transverse test bars. Average tension test results are shown in Table I.

Figure 1 shows relation between tensile strength and diameter of test bar as cast, and in Fig. 2 the Brinell hardness values have been plotted against the diameter of test bar as cast.

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[1] Director of Laboratories, Deere and Co., Moline, Ill.

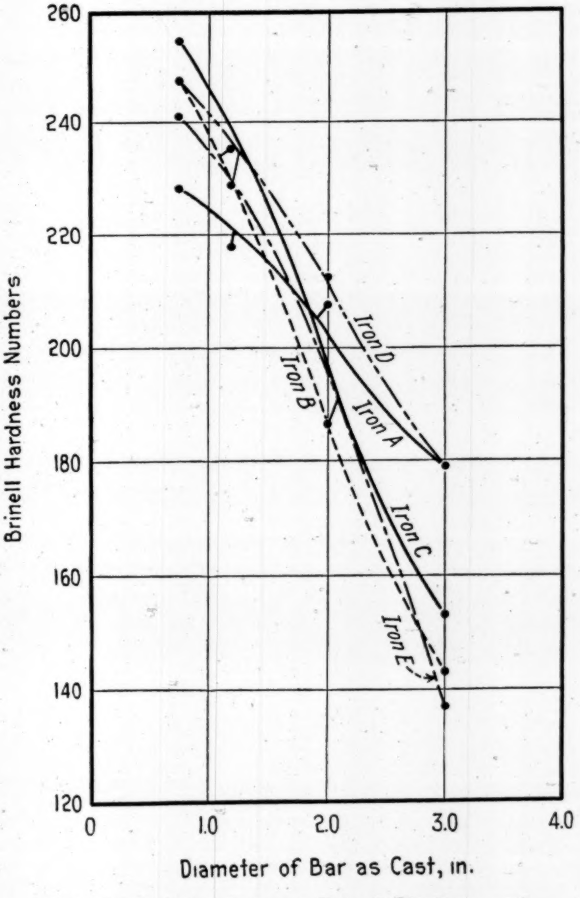


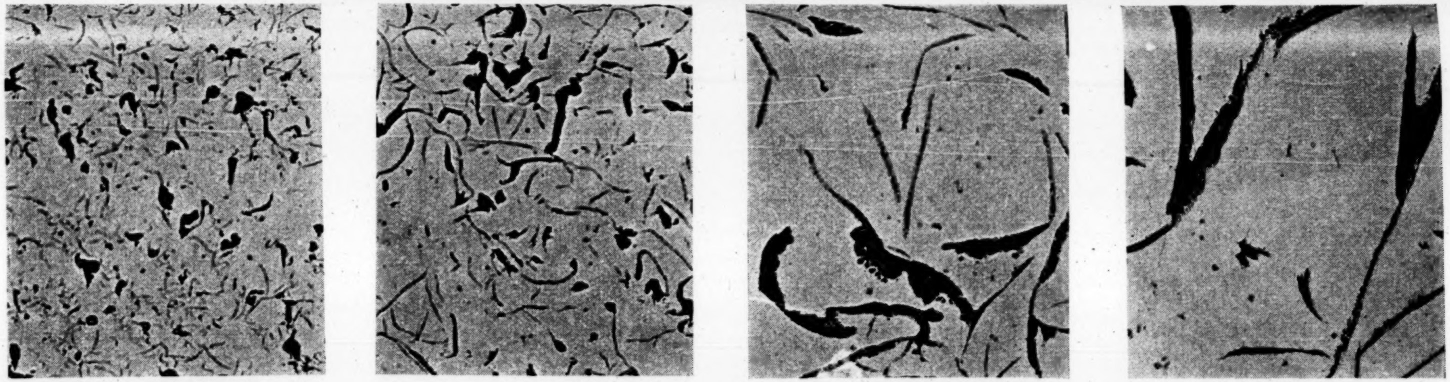
FIG. 2.—Relation Between Brinell Hardness and Diameter of Test Bar as Cast.

Photomicrographs at 100 diameters, unetched, and at 250 diameters, etched with 5-per-cent Nital, were made on each set of test bars. These photomicrographs are reproduced in Figs. 3 to 7.

It should be pointed out that a higher-strength iron shows less falling off in physical properties from light to heavy section. From Table I it will be noted there is a falling off in tensile strength on iron E (a low-strength iron with no steel used in the mix) as compared with iron D (a much stronger iron having 12 per cent of steel in the mix). The differences in micro-structure should also be noted from Figs. 5 and 6.

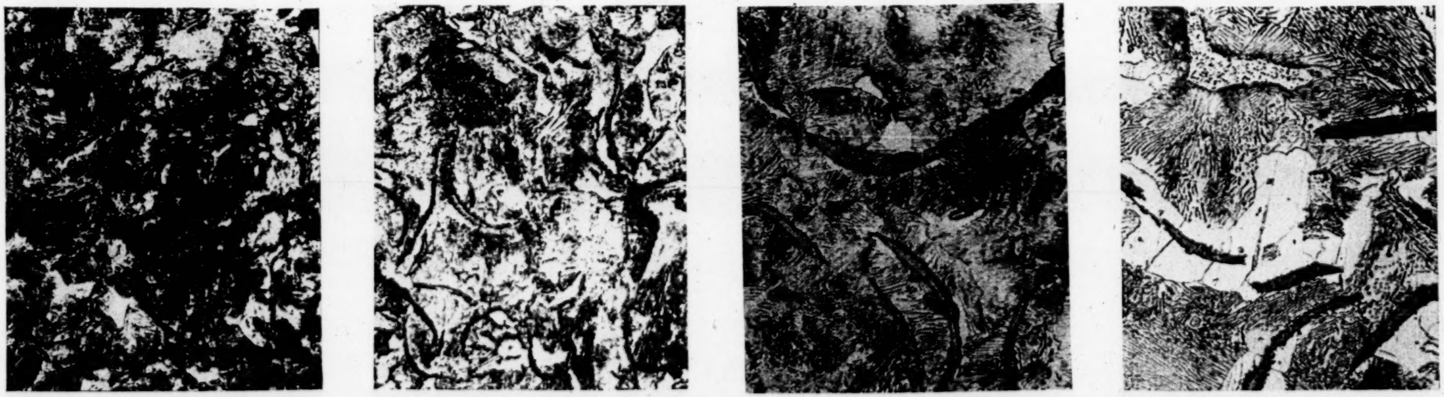
TABLE I.—AVERAGE RESULTS OF CHEMICAL AND PHYSICAL TESTS OF TEST BARS REPRESENTING CAST IRONS FROM FIVE FOUNDRIES.

	IRON A	IRON B	IRON C	IRON D	IRON E
CHEMICAL ANALYSES					
Silicon, per cent	2.21	2.15	2.42	2.14	2.39
Sulfur, per cent	0.078	0.082	0.083	0.086	0.077
Phosphorus, per cent	0.54	0.66	0.49	0.18	0.58
Manganese, per cent	0.59	0.48	0.57	0.74	0.59
Carbon, per cent	3.30	3.47	3.25	3.31	3.42
PHYSICAL TESTS ON 3-IN. DIAMETER BAR					
Distance between supports, in	24	24	24	24	24
Transverse strength, lb	20 653	14 332	23 495	25 210	14 363
Deflection, in	not determined				
Tensile strength, lb. per sq. in	18 600	14 380	22 700	24 540	12 100
Brinell hardness	179	143	153	179	137
PHYSICAL TESTS ON 2-IN. DIAMETER BAR					
Distance between supports, in	24	24	24	24	24
Transverse strength, lb	7 248	5 132	8 250	7 950	5 140
Deflection, in	not determined				
Tensile strength, lb. per sq. in	24 150	18 080	27 450	30 900	15 420
Brinell hardness	207	187	207	212	187
PHYSICAL TESTS ON 1.2-IN. DIAMETER BAR					
Distance between supports, in	18	18	18	18	18
Transverse strength, lb	2 202	1 621	2 452	2 298	1 578
Deflection, in	0.25	0.23	0.28	0.26	0.21
Tensile strength, lb. per sq. in	35 210	25 430	35 960	36 870	23 590
Brinell hardness	217	228	228	235	235
PHYSICAL TESTS ON 0.75-IN. DIAMETER BAR					
Distance between supports, in	12	12	12	12	12
Transverse strength, lb	921	718	1 049	946	765
Deflection, in	0.17	0.17	0.14	0.185	0.14
Tensile strength, lb. per sq. in	36 475	27 200	37 500	37 375	28 825
Brinell hardness	228	248	255	248	241



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

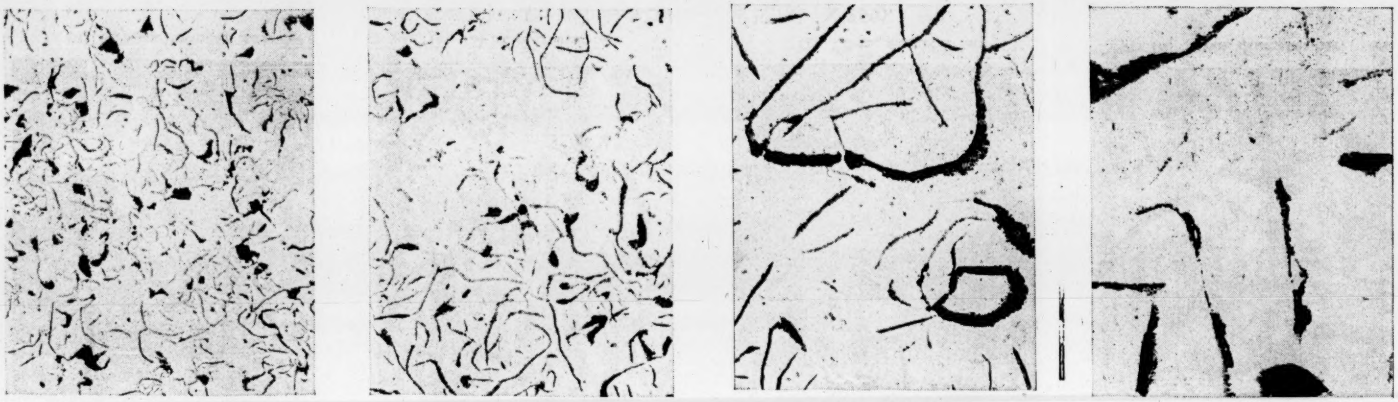
Unetched (× 100).



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

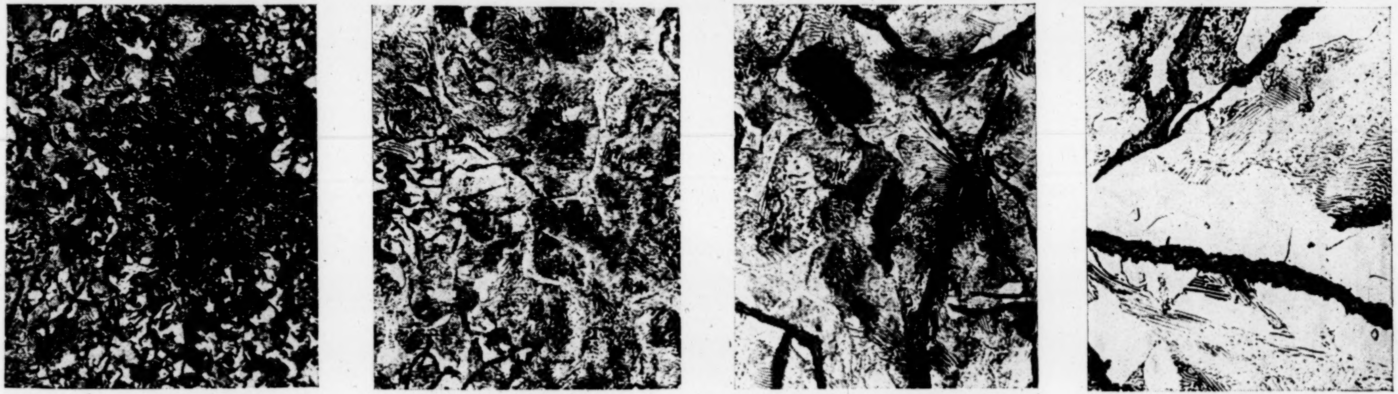
Etched with 5-per-cent Nital (× 250).

FIG. 3.—Photomicrographs of Iron A, 5 per cent of Steel Used in Charge.



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

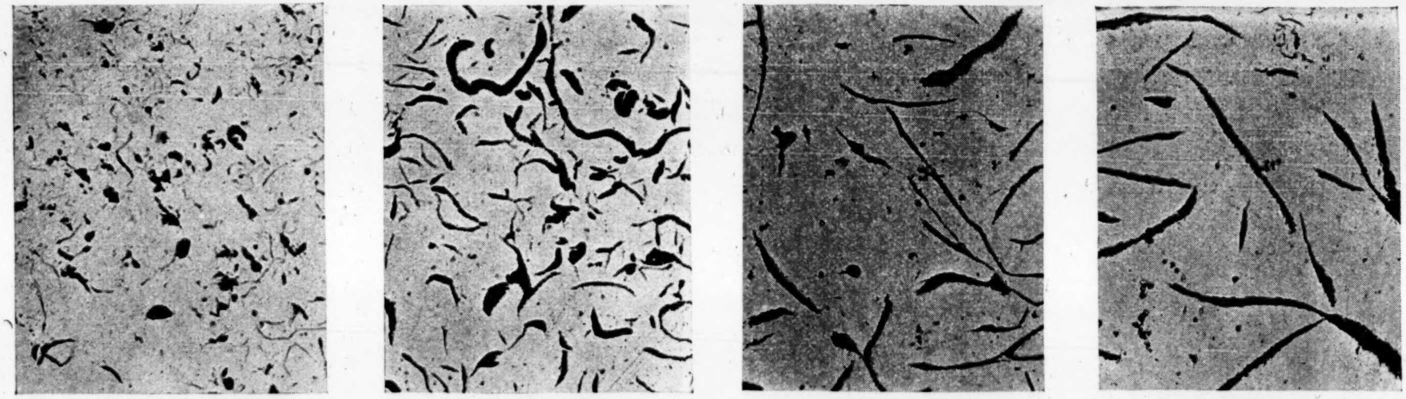
Unetched (× 100).



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

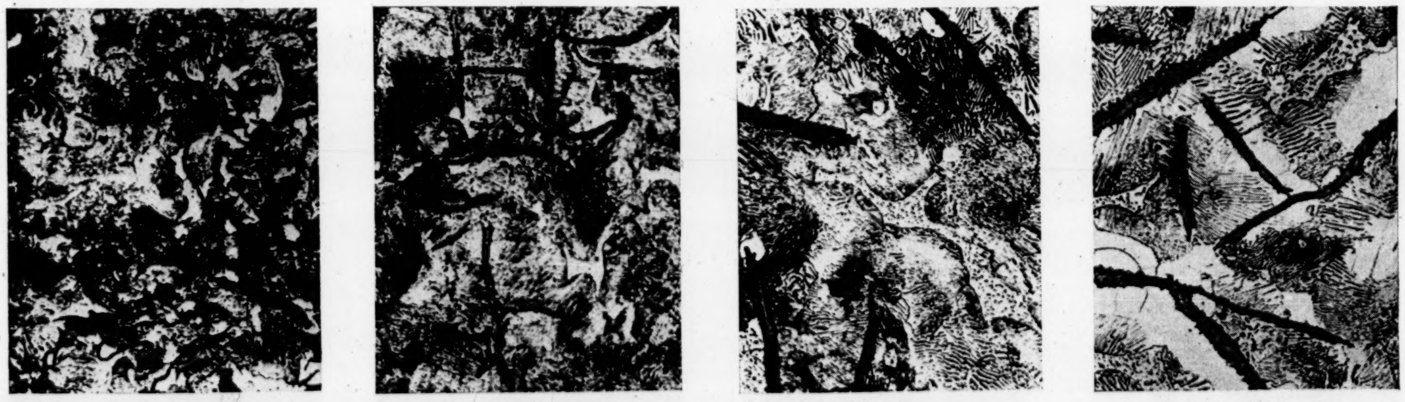
Etched with 5-per-cent Nital (× 250).

FIG. 4.—Photomicrographs of Iron B, 0 per cent of Steel Used in Charge.



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

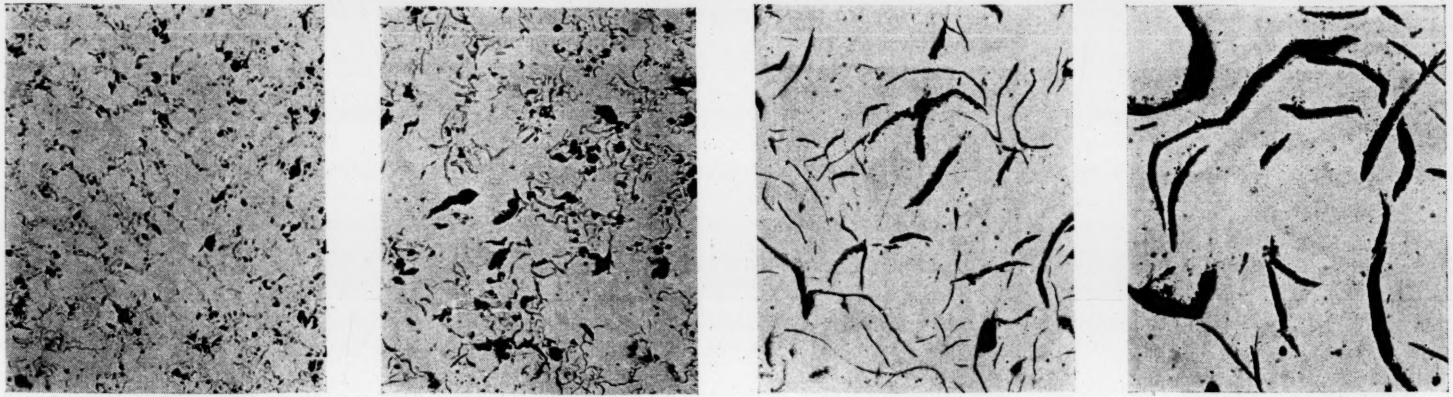
Unetched (× 100).



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

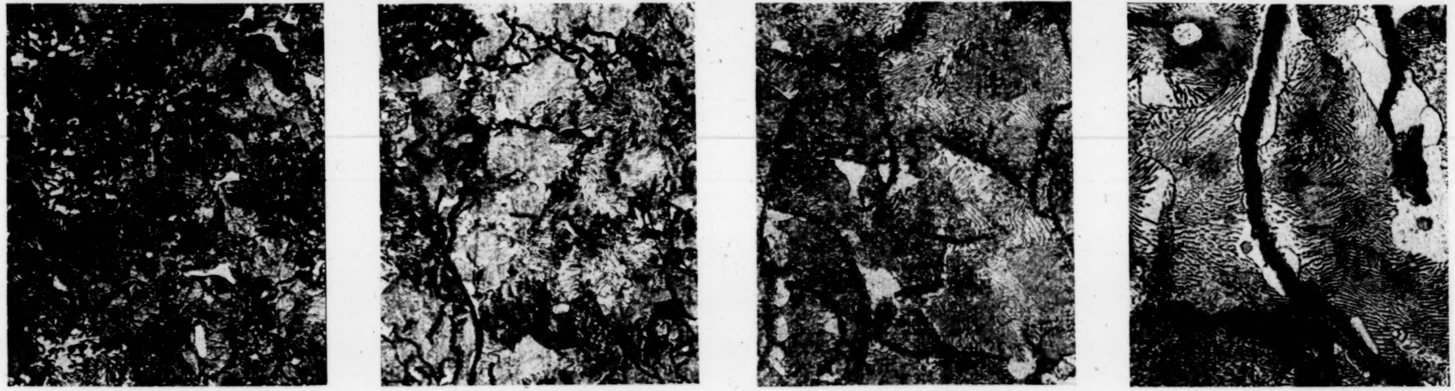
Etched with 5-per-cent Nital (× 250).

FIG. 5.—Photomicrographs of Iron C, 10 per cent of Steel Used in Charge.



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

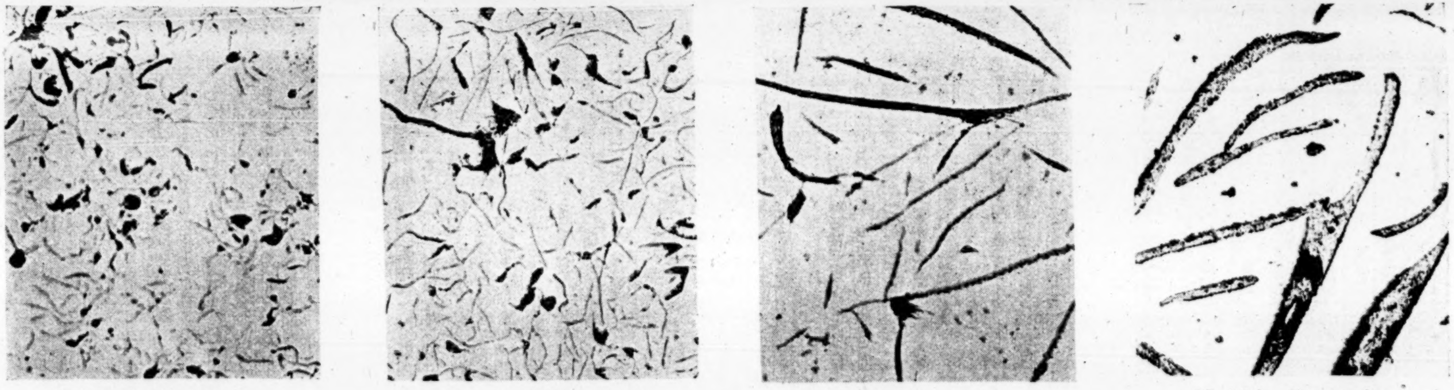
Unetched (× 100).



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

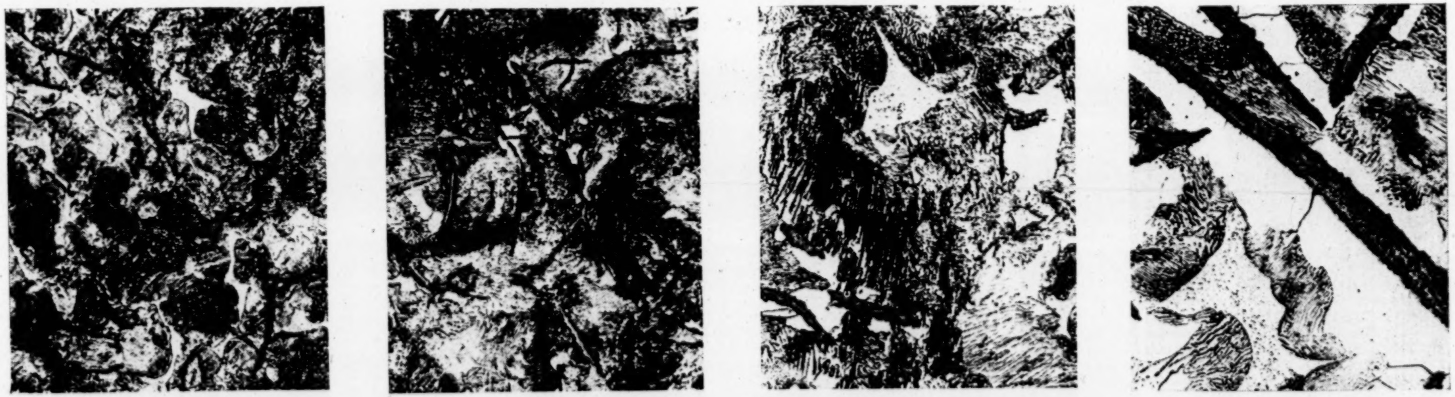
Etched with 5-per-cent Nital (× 250).

FIG. 6.—Photomicrographs of Iron D, 12 per cent of Steel Used in Charge.



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

Unetched (× 100).



(*a*) 0.75-in. diameter bar. (*b*) 1.2-in. diameter bar. (*c*) 2.0-in. diameter bar. (*d*) 3.0-in. diameter bar.

Etched with 5-per-cent Nital (× 250).

FIG. 7.—Photomicrographs of Iron E, 0 per cent of Steel Used in Charge.

APPENDIX II

TESTS ON CAST-IRON SPECIMENS OF VARIOUS DIAMETERS

By J. T. MacKenzie[1]

This paper covers an investigation made to determine the constancy of the relationship between the three test bars for cast iron proposed as standard, ⅞ in., 1.20 in. and 2.20 in. in diameter, which are modeled on the British specification.

It appeared to the author that for the transverse test specimen the span on the large bar, 2.2 in. in diameter, would be much better set at 24 in. than at 18 in. as is the case with the present arbitration bar, since the load necessary for breaking would not be so high and the deflection would be considerably greater. With that end in view a considerable number of the 2.2-in. diameter bars were broken on both 18 and 24-in. spans.

The bars were cast vertically in individual molds rammed in standard 6-in. steel pipe, with a number of vent holes. The molds were of ordinary pipe foundry sand, which is coarse and strong, blacked with an emulsion of coke dust while green, and thoroughly dried in an oven, set up on a hot fire brick, poured open-top with no runner of any kind, and in all cases left in the mold over night.

The variations in diameter were seldom greater than 0.05 in. from the standard and the results reported for load and deflection are in all cases corrected for those variations. The deflections on the ⅞-in. diameter bars and the 1.20-in. diameter bars were recorded together with the load on an autographic Riehle transverse machine described by the author in 1924.[2] The 2.20-in. diameter bars were broken on a 50,000-lb. Olsen machine, with a deflection meter reading to 0.001 in. Three observers were employed, one watched the deflection meter, another kept the beam balanced and the third recorded the data and read the beam when the first observer called stated increments of deflection. These results were then plotted and examined for inaccuracies which could readily be detected when the readings were plotted. It is believed that the error in no case exceeds 5 per cent and in most cases is probably less than 3 per cent.

After the main portion of the work had been performed, a few irons were tested, five sets in number, which were cast 0.2-in. over size on the diameter and which were then machined down to the standard diameter. This removed all surface irregularities, such as are found in sand castings, and the results can be relied upon very much better than the other bars. Unfortunately, the small bars were poured too cold in set No. 35 so that the modulus of rupture is low and the modulus of elasticity is high.

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[1] Chief Chemist, American Cast Iron Pipe Co., Birmingham, Ala.

[2] J. T. MacKenzie, "The Standard Test Bar for Cast-Iron Pipe with Special Reference to Its Progressive Deflection," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 664 (1924).

TABLE I.—CHEMICAL COMPOSITIONS AND PHYSICAL PROPERTIES OF CAST-IRON TEST BARS OF VARIOUS DIAMETERS.

Set Number	Process of Manufacture	Chemical Composition, per cent							Physical Properties																Brinell Hardness Numbers									Difference Between Edge Readings of $\frac{7}{8}$-in. and 2.20-in. Bars
									1.20-in. Diameter Bar Tested on 18-in. Span				$\frac{7}{8}$-in. Diameter Bar Tested on 12-in. Span				2.20-in. Diameter Bar Tested on 18-in. Span				2.20-in. Diameter Bar Tested on 24-in. Span				$\frac{7}{8}$-in. Diameter Bar			1.20-in. Diameter Bar			2.20-in. Diameter Bar			
		Carbon	Silicon	Phosphorus	Manganese	Sulfur	Nickel	Chromium	Load, lb.	Modulus of Rupture, lb. per sq. in.	Deflection, in.	Modulus of Elasticity, lb. per sq. in.	Load, lb.	Modulus of Rupture, lb. per sq. in.	Deflection, in.	Modulus of Elasticity, lb. per sq in.	Load, lb.	Modulus of Rupture, lb. per sq. in.	Deflection, in.	Modulus of Elasticity, lb. per sq. in.	Load, lb.	Modulus of Rupture, lb. per sq. in.	Deflection, in.	Modulus of Elasticity, lb. per sq. in.	Edge	Middle	Difference	Edge	Middle	Difference	Edge	Middle	Difference	
1	Cupola...	3.60	1.50	0.72	0.53	0.08	.....	....	2 090	55 300	0.219	11 400 000	1 230	56 100	0.134	11 500 000	12 600	54 200	0.137	9 700 000	9 800	56 200	0.260	9 400 000	207	196	11	212	179	33	179	156	23	28
2	"	3.63	1.58	0.81	0.30	0.07	.....	....	1 760	46 700	0.194	10 800 000	1 060	48 300	0.097	13 700 000	10 400	44 700	0.139	7 900 000	6 700	38 400	0.187	9 000 000	207	192	15	187	170	17	179	148	31	28
3	"	3.55	1.80	0.84	0.49	0.06	.....	....	1 850	49 000	0.210	10 500 000	1 120	56 000	0.102	13 800 000	10 300	44 300	0.132	8 200 000	7 150	41 000	0.200	9 000 000	202	192	10	196	163	33	179	148	31	23
4	"	3.35	1.24	0.65	0.37	0.09	.....	....	2 300	60 900	0.209	13 200 000	1 440	65 600	0.118	15 300 000	13 470	57 800	0.124	11 500 000	10 750	61 700	0.245	11 000 000	228	212	16	228	202	26	202	183	19	26
5	"	3.24	1.16	0.64	0.37	0.08	.....	....	2 430	64 400	0.213	13 600 000	1 490	67 900	0.125	14 900 000	15 000	64 500	0.129	12 300 000	10 740	61 700	0.233	11 600 000	235	228	7	228	207	21	196	163	33	39
6	"	3.35	1.00	0.65	0.30	0.08	.....	....	2 490	66 000	0.206	14 500 000	1 600	72 900	0.128	15 700 000	14 560	62 600	0.123	12 400 000	9 600	55 100	0.175	14 800 000	255	235	20	235	207	28	212	179	33	76
7	"	3.56	1.62	0.65	0.54	0.08	.....	....	2 200	58 300	0.248	10 600 000	1 330	60 600	0.132	12 600 000	12 060	51 800	0.146	8 700 000	9 050	51 800	0.238	9 600 000	212	207	5	202	187	15	187	159	28	25
8	"	3.40	1.32	0.47	1.57	0.10	.....	....	2 310	61 200	0.204	13 500 000	1 430	65 200	0.114	15 600 000	15 100	64 900	0.123	13 000 000	10 800	62 100	0.200	13 500 000	...	...	...	...	...	...	...	...	..	....
9[a]	Elec. Fur.	2.69	1.60	0.51	0.27	0.06	12.20	1.45	1 900	50 300	0.208	10 900 000	1 035	47 200	0.134	9 700 000	11 600	49 800	0.138	8 900 000	.....	......	.....	....	153	146	7	156	149	7	156	149	7	−3
10	"	2.79	1.41	0.15	1.06	0.06	1.98	0.66	2 240	59 300	0.114	23 500 000	1 600	72 900	0.075	26 700 000	15 500	66 600	0.091	18 000 000	.....	......	.....	....	460	387	73	387	387	0	321	269	52	139
11	"	2.59	1.96	0.17	0.95	0.06	1.81	0.60	2 540	67 300	0.158	19 200 000	1 500	68 300	0.099	18 900 000	16 000	68 800	0.094	18 000 000	.....	......	.....	....	302	293	9	286	269	17	248	248	0	54
12	"	2.45	2.43	0.22	0.85	0.05	2.00	0.61	2 440	64 700	0.145	20 100 000	1 490	67 900	0.088	21 200 000	14 500	62 300	0.081	19 000 000	.....	......	.....	....	302	286	16	286	277	9	277	277	0	25
13	"	3.09	1.66	0.26	0.53	0.05	1.97	0.56	2 480	65 700	0.201	14 800 000	1 360	61 900	0.104	16 300 000	15 200	65 300	0.119	13 500 000	.....	......	.....	....	269	269	0	262	248	14	228	207	21	41
14	"	3.04	1.94	0.20	0.68	0.05	1.96	0.54	2 400	63 600	0.184	15 600 000	1 480	67 400	0.102	18 200 000	16 000	68 800	0.112	15 100 000	.....	......	.....	....	269	269	0	262	235	27	241	223	18	28
15	"	2.98	2.47	0.22	0.66	0.05	1.91	0.56	2 620	69 400	0.180	17 400 000	1 670	76 100	0.117	17 800 000	16 600	71 300	0.104	16 900 000	.....	......	.....	....	277	269	8	269	269	0	255	255	0	22
16	"	3.34	1.44	0.24	0.65	0.09	1.64	0.42	2 470	65 500	0.189	15 600 000	1 440	65 700	0.111	16 200 000	16 000	68 700	0.118	14 400 000	.....	......	.....	....	277	255	22	255	241	14	228	207	21	49
17	"	3.36	1.94	0.21	0.72	0.07	1.71	0.36	2 330	61 700	0.204	13 600 000	1 380	67 800	0.118	14 600 000	14 100	60 600	0.125	11 900 000	.....	......	.....	....	255	241	14	241	212	29	212	196	16	43
18	"	3.47	1.64	0.20	0.78	0.07	1.69	0.35	2 360	62 500	0.206	13 700 000	1 600	72 900	0.131	15 300 000	14 850	63 800	0.129	12 200 000	.....	......	.....	....	255	235	20	228	223	5	207	192	15	48
19	"	2.77	1.60	0.13	1.01	0.05	1.99	0.52	2 350	62 300	0.146	19 200 000	1 570	71 600	0.079	24 800 000	16 750	72 000	0.107	16 500 000	.....	......	.....	....	418	375	43	311	286	25	269	248	21	149
20	"	2.77	1.80	0.16	0.86	0.05	1.98	0.49	2 530	67 000	0.178	17 000 000	1 510	69 700	0.097	19 400 000	15 100	64 900	0 102	15 600 000	.....	......	.....	....	286	286	0	277	269	8	262	255	7	24
21	"	2.82	2.20	0.17	0.82	0.04	1.96	0.47	2 630	69 700	0.185	17 000 000	1 540	70 200	0.096	20 100 000	15 500	66 700	0.102	16 100 000	.....	......	.....	....	293	286	7	286	269	17	255	241	14	38
22[b]	"	2.89	2.22	0.37	1.52	0.05	12.85	2.34	1 910	50 600	0.255	9 000 000	1 230	56 100	0.181	8 500 000	.....	......	.....	....	7 400	42 400	0.237	7 800 000	140	134	6	143	131	12	107	105	2	33
23	Cupola...	4.00	1.04	0.08	0.64	0.08	.....	....	1 650	43 700	0.254	7 800 000	990	45 100	0.135	9 200 000	.....	......	.....	....	5 600	32 100	0.226	6 200 000	159	156	3	159	149	10	121	103	18	38
24	Elec. Fur.	3.48	2.97	0.05	0.68	0.05	.....	....	1 755	46 500	0.228	9 200 000	1 020	46 500	0.117	10 900 000	.....	......	.....	....	5 820	33 400	0.274	5 300 000	187	181	6	162	163	−1	143	131	12	44
25	"	2.96	2.86	0.06	0.70	0.05	.....	....	2 190	58 000	0.204	12 800 000	1 370	67 400	0.118	14 500 000	.....	......	.....	....	9 940	57 000	0.247	10 100 000	228	228	0	217	212	5	192	179	13	36
26	"	2.54	3.05	0.04	0.70	0.07	.....	....	2 230	59 100	0.146	18 300 000	1 495	68 100	0.079	23 600 000	.....	......	.....	....	10 220	58 700	0.174	14 700 000	269	269	0	262	248	14	241	217	24	28
27	"	3.46	1.69	0.04	0.56	0.06	.....	....	1 975	52 300	0.230	10 300 000	1 220	56 600	0.100	15 500 000	.....	......	.....	....	9 120	52 300	0.265	8 600 000	217	217	0	196	192	4	179	170	9	38
28	"	2.71	2.88	0.04	0.45	0.06	.....	....	2 450	65 000	0.179	16 400 000	1 610	73 300	0.109	18 500 000	.....	......	.....	....	11 500	66 100	0.232	11 900 000	255	248	7	241	196	45	217	196	21	38
29	Cupola...	3.69	2.08	0.18	0.51	0.11	.....	....	2 280	60 400	0.309	8 750 000	1 560	71 200	0.173	11 300 000	12 010	51 600	0.177	7 200 000	8 550	49 000	0.309	6 900 000	212	196	14	196	187	9	170	143	27	42
30	"	3.16	1.59	0.46	0.49	0.12	.....	....	2 670	70 800	0.225	14 200 000	1 490	67 900	0.122	15 300 000	16 120	69 300	0.142	12 000 000	.....	......	.....	....	241	228	13	241	217	24	207	179	28	34
31	"	3.14	1.46	0.44	0.54	0.12	.....	....	2 600	68 800	0.240	12 950 000	1 680	76 600	0.139	15 100 000	15 800	67 900	0.138	12 100 000	11 600	66 600	0.226	12 800 000	228	228	0	228	207	21	207	196	11	21
32[c]	"	3.46	1.48	0.67	0.52	0.07	.....	....	2 420	64 200	0.278	10 400 000	1 620	73 700	0.164	12 300 000	14 300	61 500	0.160	9 400 000	9 860	56 700	0.242	10 200 000	207	196	11	196	183	13	196	170	26	11
33[c]	"	3.24	1.80	0.47	0.52	0.11	.....	....	2 925	77 500	0.310	11 300 000	1 725	78 500	0.168	12 800 000	16 290	70 100	0 186	9 300 000	11 740	67 500	0.295	10 000 000	223	217	6	217	207	10	196	170	26	27
34[c]	Elec. Fur	3.51	2.00	0.56	0.57	0.05	.....	....	2 255	59 700	0.261	10 300 000	1 500	68 300	0.170	11 000 000	12 020	51 700	0.149	8 700 000	8 870	50 900	0.263	8 400 000	202	202	0	196	174	22	179	149	30	23
35[c]	Mixed[d] ..	2.61	1.60	0.51	0.63	0.07	.....	....	2 700	71 600	0.172	18 700 000	1 330	60 600	0.095	17 500 000	17 950	77 200	0.125	15 200 000	13 200	75 800	0.215	15 400 000	248	248	0	241	228	13	223	217	6	25
36[c]	Cupola	3.71	1.74	0.49	0.49	0.06	.....	....	1 970	52 500	0.354	6 700 000	1 220	55 600	0.214	7 100 000	10 600	45 600	0 200	5 600 000	7 650	43 900	0.329	5 800 000	163	156	7	159	153	6	149	126	23	14

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[a] Copper content, 4.88-per-cent.

[b] Copper content, 5.82-per-cent.

[c] These sets were cast 0.2-in. oversize and machined to standard diameter.

[d] Cupola iron mixed with electric-furnace steel.

Table I shows all of the chemical and physical test data. The load and deflection are stated in pounds and inches, respectively. The modulus of rupture, calculated from the conventional beam formula, and the modulus of elasticity (so called) are given in pounds per square inch. In this connection it should be borne in mind that the modulus of rupture and modulus of elasticity are based on certain mathematical assumptions which are not true for cast iron and that, therefore, they are no more than indexes of the strength and of the stiffness of the metal, respectively. The modulus of elasticity as used here should no more be compared to the modulus of elasticity as used in steel than the modulus of rupture here should be taken to represent tensile strength.

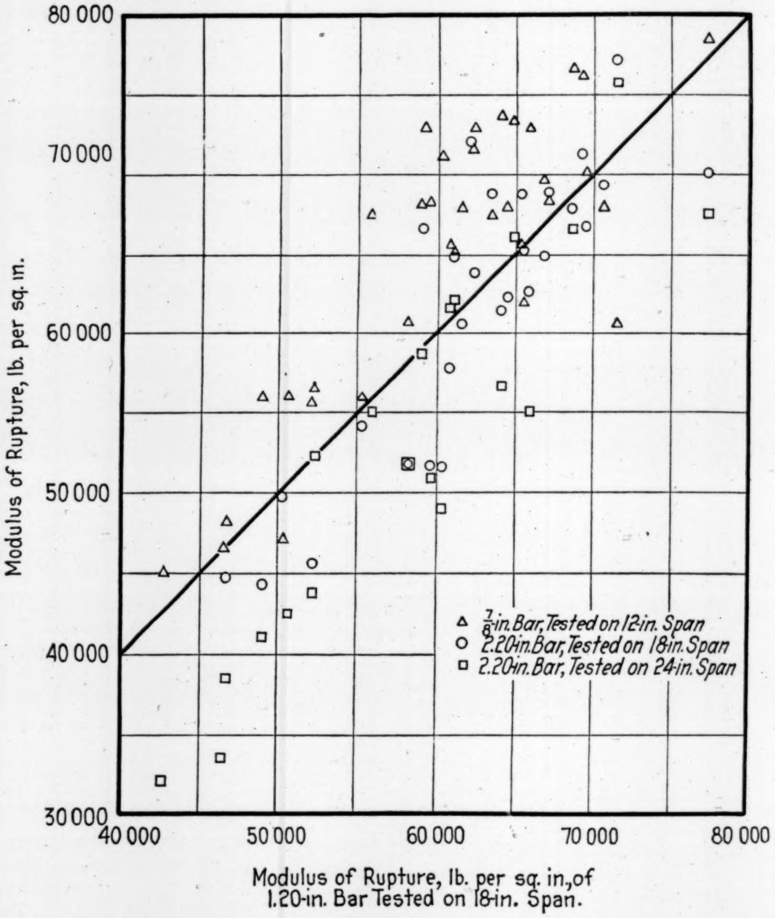

FIG. 1.—Relation Between Modulus of Rupture of the 1.20-in. Bar Tested on 18-in. Span and the $\frac{7}{8}$-in. and 2.20-in. Bars Tested on Various Span Lengths.

Figures 1 and 2 show the value for modulus of rupture and modulus of elasticity, respectively, plotted against the values for the 1.20-in. diameter bar tested on an 18-in. span. The characters differentiate between the ⅞-in. diameter bar and the two span lengths used with the 2.20-in. diameter bar. The small bars lie consistently above the line and the large bars are fairly well below it. The lines drawn in the two figures simply denote equal values on both scales and have no reference to the distribution of the points.

In Figs. 3 and 4 the modulus of rupture and modulus of elasticity are plotted for the 2.20-in. diameter bars, the vertical scale representing the 24-in. span and the horizontal scale representing the 18-in. span. It is perfectly evident from these two figures that the only reason for choosing one span rather than the other is simply a matter of convenience, as the values for the moduli do not vary enough to cause any concern.

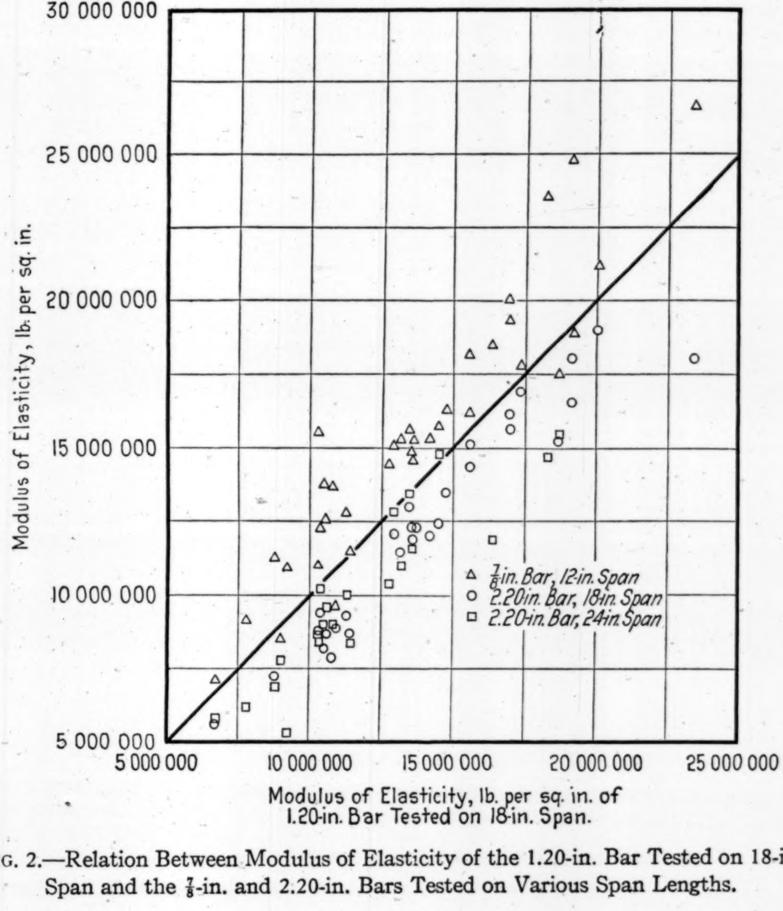

Fig. 2.—Relation Between Modulus of Elasticity of the 1.20-in. Bar Tested on 18-in. Span and the ⅞-in. and 2.20-in. Bars Tested on Various Span Lengths.

Results of the Brinell hardness tests are given in Table I. The author believed, in originating the work, that the difference in properties between the ⅞-in. diameter bar and the 2.20-in. diameter bar could be predicted from the properties of the 1.20-in. bar itself. With that end in view, in Table II, the differences between the Brinell hardness at the edge and middle of the bar has been stated as well as the differences in the edge hardness of the $\frac{7}{8}$-in. bar

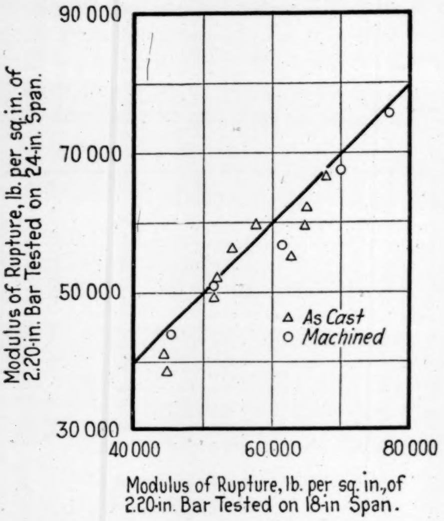

FIG. 3.—Relation of Modulus of Rupture Results of the 2.20-in. Bar Tested on the 18-in. and the 24-in. Spans.

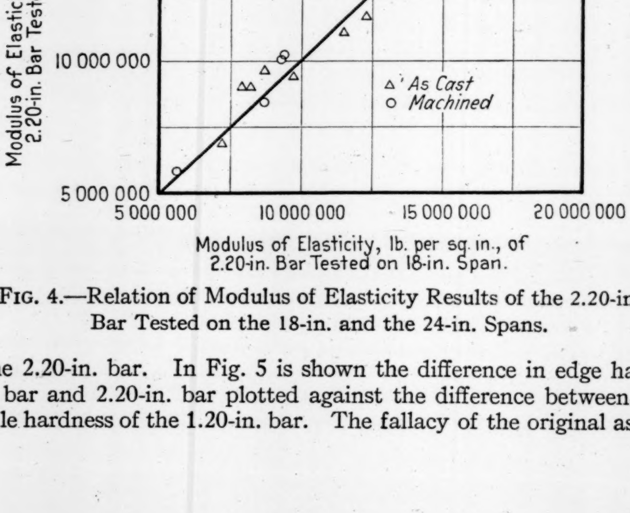

FIG. 4.—Relation of Modulus of Elasticity Results of the 2.20-in. Bar Tested on the 18-in. and the 24-in. Spans.

and of the 2.20-in. bar. In Fig. 5 is shown the difference in edge hardness of the $\frac{7}{8}$-in. bar and 2.20-in. bar plotted against the difference between the edge and middle hardness of the 1.20-in. bar. The fallacy of the original assumption is clearly evident, as the scattered character of plotted results of Fig. 5 attests. The line again simply shows the position of equal values on both scales and is not intended to represent any distribution of points.

As an illustration of the 2.20-in. bar, the following table shows the results on a 10-in. diameter test bar cast 36 in. in length, from which bars 2.20 in. in diameter were milled out in the positions as shown on Fig. 6 and were subsequently turned down and tested. Results on a separately cast bar of the same size are also given:

	BARS 2.20 IN. IN DIAMETER MILLED FROM 10-IN. BAR						SEPARATELY CAST BAR
	BAR A	BAR B	BAR C	BAR D	BAR E	BAR F	
Distance between supports, in.	24	24	24	24	24	24	24
Transverse strength, lb.	13 070	12 470	12 825	12 020	12 730	12 710	13 070
Deflection, in.	0.330	0.290	0.313	0.328	0.295	0.310	0.214
Tensile strength, lb. per sq. in.	....	....	....	38 600	....	39 000	....
Brinell hardness	....	....	....	205	....	207	238

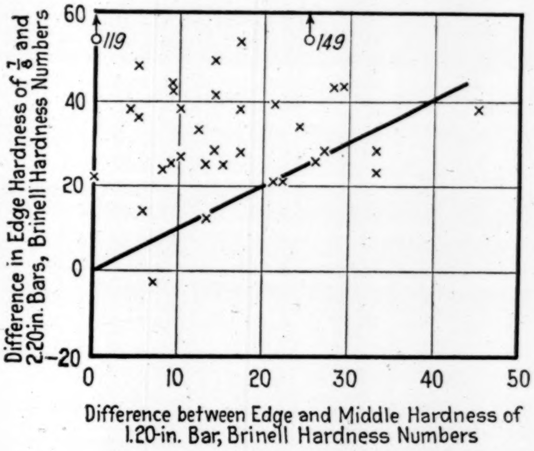

FIG. 5.—Relation Between Differences in Brinell Hardness Values of Various Diameter Test Bars.

The following chemical analysis of the separately cast bar includes complete analysis for all probable metalloids and alloys. The feature of the analysis is the molybdenum content which was made as a ladle addition of ferro-molybdenum to the cupola metal. The mixture contained 70 per cent of steel rails:

Carbon, per cent	3.05
Silicon, per cent	1.22
Sulfur, per cent	0.09
Manganese, per cent	1.16
Phosphorus, per cent	0.30
Molybdenum, per cent	0.90
Vanadium, per cent	0.06
Nickel, per cent	0.03
Chromium, per cent	0.03

It will be noted from the above results that the separately cast test bar in this case represented fairly well the strength, even of the 10-in. diameter bar. The deflection, however, is considerably lower on the separately cast bar and the Brinell hardness is higher. Probably some intermediate size would have shown higher strength than either the 10-in. or the 2-in. diameter bars. A 2 by 1-in. test bar cast from the same metal showed a Brinell hardness of 300.

The tensile strengths shown were on the U. S. Ordnance standards for cast iron, the bars being turned down to a diameter of 1.129 in. with a 1-in. gage length.

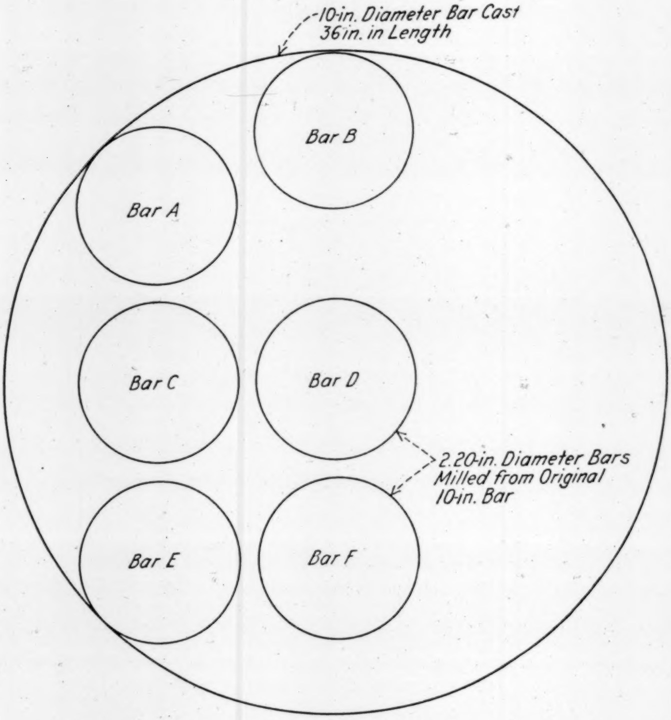
10-in. Diameter Bar Cast 36 in. in Length
Bar B
Bar A
Bar C
Bar D
2.20-in. Diameter Bars Milled from Original 10-in. Bar
Bar E
Bar F

FIG. 6.—Location of 2.20-in. Bars Milled from 10-in. Bar.

In presenting these data, the author trusts that their presentation will further the work of Subcommittee XIV on Correlation of Test Bar and Casting and that it will hasten the adoption of three sizes of test bars, either those already standardized in England or some other sizes. The author personally would favor the adoption of those already established, but he believes that the general principle is unquestionably of great value.

APPENDIX III

CORRELATION OF CAST-IRON TEST BAR AND CASTING BY VOLUME-SURFACE RATIO

By J. W. Bolton[1]

Within the past few years both consumers and producers, recognizing the futility of judging irons by test bars whose avowed purpose is to establish the "quality of iron in the ladle," have sought better methods of ascertaining the actual quality of iron in the casting. The only positive and final test is the service test. The difficulty of making service tests commercially prevents their adoption except in isolated cases. Direct tests made on sections from castings are valuable in research work, but with few exceptions offer almost insuperable objections from a commercial viewpoint—so much so that aside from rare cases, specifications calling for direct tests made on sections from castings are impractical or misleading or both. A practical solution for the problem is the selection of several sized separately cast bars to represent various section sizes in castings, plus data, in recommended practices, which will facilitate the interpretation of the test bar data.

This paper suggests a method of correlation based on the relationship of cooling rate (approximated by mathematical calculation) of the casting or castings compared to the cooling rate of the test bar, thus suggesting the proper size of bar to be chosen to represent the more important section in the casting. It should be emphasized at the outset that although this method has proved very useful on certain types of castings, it possesses certain limitations. However, assuming good workmanship (foundry practice), the observed variations have been on the conservative side, that is, direct test results from castings either have been equal to or higher than the calculated results.

As indicated in an earlier paper by the author[2] the causative factors or variables determining the physical properties of gray iron are as follows:

1. Chemical composition—initial, incidental and final;
2. Structural and mechanical makeup of charge;
3. Melting process;
4. Thermal and mechanical history—furnace spout to cooled casting; and
5. Design and workmanship.

For a given heat to be poured into test bars and castings, factors 1, 2 and 3 are alike for both castings and bars. The conditions in factor 4 can be simulated to a large degree for bar and casting, and in most cases the conditions in factor 5 also can be allowed for.

It is obvious that the thermal history, particularly the cooling rate of the section is very important, as the degree of graphitization varies with the cooling velocity from the liquidus to a point somewhat below the eutectoid arrest.

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[1] Chief Chemist and Metallurgist, The Lunkenheimer Co., Cincinnati, Ohio.

[2] J. W. Bolton "Classification of Gray-Iron Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 67 (1929).

If cooling rate of bar and casting section are alike (in iron from the same heat and ladle), the physical properties will be much alike, providing of course the sections are well fed.

Cooling rate depends on a number of factors, among which are the following:

1. Initial temperature (which may or may not coincide with pouring temperature).
2. Final temperature.
3. Specific heats of alloy.
4. Volume of metal to be cooled.

TABLE I.—CAST IRON TEST PIECES ARRANGED IN THE ORDER OF THEIR VOLUME-SURFACE AREA RELATIONSHIP.

Group	Size of Bar	Length Cast, in.	Length Between Supports, in.	Cross-Sectional Area, sq. in.	Surface Area, sq. in.	Volume, cu. in.	Ratio, Volume to Surface Area	Relative Modulus of Rupture	Logarithm of Modulus of Rupture
No. 1	¼ by 12 by 12 in.	..	..	.....	....	.....	0.1200	....	....
No. 2	0.500 in. diam.	21	18	0.196	33.4	4.12	0.1234	366.640	2.56425
No. 3	0.800 in. diam.	15	12	0.503	38.7	7.55	0.1951	59.672	1.77577
No. 4	0.875 in. diam.	21	18	0.601	58.9	12.6	0.2139	68.414	1.83514
No. 5	½ by 12 by 12 in.	..	..	.....	....	....	0.2308	......	....
No. 6	1.00 in. diam.	15	12	0.785	48.7	11.8	0.2423	30.552	1.48504
No. 7	1.00 in. diam.	21	18	0.785	67.5	16.5	0.2444	45.831	1.66116
No. 8	1 by 1 in.	27	24	1.00	110.0	27.0	0.2455	36.0	1.55630
No. 9	1.20 in. diam.	21	18	1.131	81.4	23.8	0.2924	26.523	1.42362
No. 10	1.25 in. diam.	15	12	1.227	61.4	18.4	0.2997	15.666	1.19496
No. 11	1.30 in. diam.	21	18	1.327	88.4	27.9	0.3156	20.860	1.31931
No. 12	2 by 1 in.	27	24	2.00	166.0	54.0	0.3253	18.0	1.25527
No. 13	1 by 2 in.	27	24	2.00	166.0	54.0	0.3253	9.0	0.95424
No. 14	1.40 in. diam.	21	18	1.539	95.4	32.3	0.3386	16.702	1.22277
No. 15	1.50 in. diam.	15	12	1.767	74.2	26.5	0.3571	9.052	0.95674
No. 16	1.50 in. diam.	21	18	1.767	102.5	37.1	0.3620	13.579	1.13287
No. 17	1.5 by 1.5 in.	27	24	2.25	166.5	60.75	0.3650	10.67	1.02816
No. 18	1 by 12 by 12 in.	..	..	.....	.....	.....	0.4286	......	....
No. 19	2.00 in. diam.	15	12	3.142	100.5	47.1	0.4686	3.819	0.58195
No. 20	2.00 in. diam.	21	18	3.142	138.2	66.0	0.4776	5.7288	0.75806
No. 21	2 by 2 in.		24	4.00	224.0	108.0	0.4820	4.500	0.65321
No. 22	2.20 in. diam.	21	18	3.801	152.7	79.8	0.5226	4.3042	0.63389
No. 23	2.50 in. diam.	21	18	4.909	174.8	103.1	0.5898	2.9332	0.46734
No. 24	2.5 by 2.5 in.	27	24	6.25	282.5	168.75	0.5980	2.303	0.36229
No. 25	3.00 in. diam.	15	12	7.069	155.5	106.0	0.6817	1.1316	0.05369
No. 26	3.00 in. diam.	21	18	7.069	212.1	148.4	0.6996	1.697	0.22968
No. 27	3 by 3 in	27	24	9.00	342.0	243.0	0.7110	1.333	0.12483
No. 28	2 by 24 by 24 in.	..	..	....	.....	.....	0.8571	.....	....
No. 29	4.00 in. diam.	15	12	12.57	213.6	188.6	0.8830	0.477	9.67852-10
No. 30	3 by 24 by 24 in.	..	..	.....	.....	.....	1.20	.....	....
No. 31	6.00 in. diam.	15	12	28.27	339.3	424.1	1.250	0.141	9.14922-10
No. 32	4 by 24 by 24 in.	..	..	.....	.....	.....	1.440	.....	....
No. 33	8.00 in. diam.	15	12	50.27	477.5	754.1	1.579	0.0596	8.77525-10

5. Metal surface area available for heat dissipation.
6. Cooling gradients within metal and mold.
7. Conductivity of mold material.
8. Speed of pouring.
9. Energy release at transformation points.
10. Mechanical factors.

Factors 1, 2 and 3 are alike or nearly so for both test bar and casting. Factors 7, 8 and 10 can be fairly well controlled.

Now the volume of metal (factor 1 controlled) is proportional to the heat energy to be dissipated or *vice versa*. The surface area is the exposed area from which this dissipation must take place. It is evident that the rate of cooling of a given casting is approximately proportional to the ratio of volume to surface area $\frac{v}{a}$, which conforms to the well known observation that cooling rate is approximately proportional to section size, but goes somewhat beyond this in better accounting for other factors.

In Table I are shown the $\frac{v}{a}$ ratios for a number of test pieces and simple shapes. Figure 1 shows that the relationship of the actual cooling rate to the $\frac{v}{a}$ ratio is practically a straight-line function.

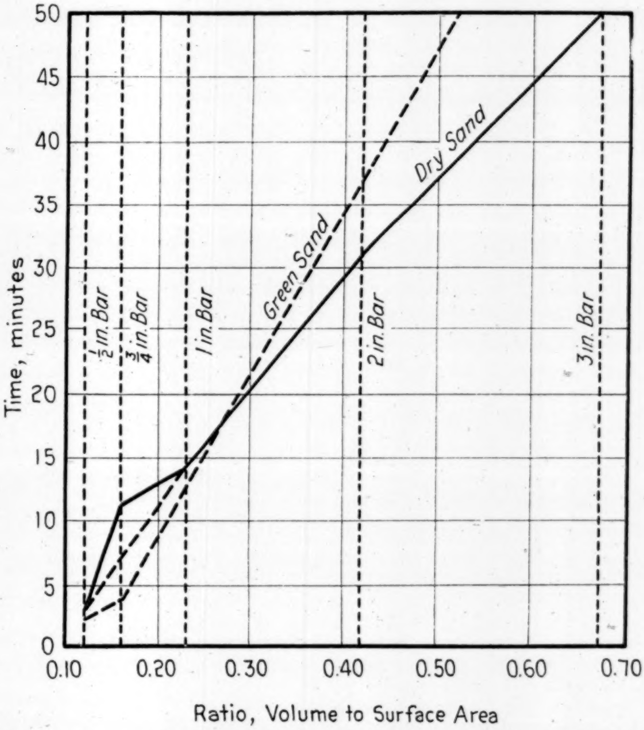

FIG. 1.—Curves Showing the Relation of Cooling Time to Ratio of Volume to Surface Area.

To utilize the table in a practical manner, compute the $\frac{v}{a}$ ratio for the casting in question and choose as the test bar to represent that casting the bar whose $\frac{v}{a}$ ratio corresponds most closely with the $\frac{v}{a}$ ratio for the casting. The computation of the $\frac{v}{a}$ ratio for castings of simple shape is not difficult. For highly complicated designs the computation may prove impracticable.

Actual comparisons of "calculated" strengths and tests taken from castings show close agreement in most instances. The variations so far met indicate that the "calculated" strengths either are close to the actual or lower; provided, of course, that the casting is sound. That is, the "calculated" strength if in error is on the conservative side. The variations observed so far have been attributable to the chilling of the casting by cores or by slow pouring and by the fact that a tension test bar taken from the center of a round test bar is at a greater distance from the surface than a bar taken from a flat or plate-like section.

A useful approximation derivable from the data indicated is that, for flat casting sections, the corresponding test bar diameter should be about twice the casting section.

In considering short cuts of the type indicated, their limitations should be clearly understood. In the present case the formula holds for simple shapes when the mold has been filled at the same rate as the test bar mold is filled. When special pouring practices are employed (the slow-pour method of Ronceray being the most notable example) variations are introduced. In the Ronceray method, extremely slow pouring modifies and speeds up the cooling rate to a very considerable degree for any given section. In this case (which the author has investigated) the calculated results are lower than the actual. When the metal has to travel over a lot of cores, etc., it again is cooled somewhat more rapidly. Chills of course upset the calculations. In castings of complicated design it is difficult to predict the true cooling rate. Variation in pouring temperature also modified the relationship.

In these doubtful cases the true cooling rate should be checked by direct pyrometry, and the proper test bar chosen from the results. A simple quick check on the method by calculation is furnished by comparative brinell hardness. While, as shown by the author[1] and others, Brinell hardness is not indicative of tensile strength on various types of iron, on a given iron of approximately constant analysis, the relationship of Brinell hardness and tensile strength is quite close. This was shown by Schuz, Rother,[2] Bolton[3] and others and lately has been investigated and promoted by Boegehold.[4] The latter has advocated its application along the lines herein suggested.

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[1] "Some Interrelationships in Gray Iron Metallurgy," *Proceedings*, Inst. British Foundrymen (1929); also *The Foundry*, Vol. 57, June 15, p. 509, July 1, p. 568 (1929).

[2] *Transactions*, Am. Foundrymen's Assn., W. H. Rother, 1926, pp. 746–765.

[3] J. W. Bolton, "On Research Problems of the Gray-Iron Foundry," *Transactions*, Am. Foundrymen's Assn., Vol. 36, p. 469 (1928).

[4] A. L. Boegehold, "Wear Testing of Cast Iron," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 115 (1929).

REPORT OF COMMITTEE A-5
ON
CORROSION OF IRON AND STEEL

Committee A-5 held two meetings during the past year. All of its work has shown substantial progress.

Subcommittee III on Inspection of the Annapolis Tests (J. H. Gibboney, chairman).—This subcommittee has held two inspections, on October 31, 1930, and April 24, 1931, which were well attended. No new failures were found at the October, 1930, inspection. Two new failures, sheets X 7 and X 12 (No. 22 gage low-copper pure iron, Series B) manufactured by the Inland Steel Co., were found at the April, 1931, inspection.

It is with profound sorrow that we record the death of Lieut. Col. F. B. Wheaton on March 14, 1931. Colonel Wheaton had been a member of this committee since the initiation of the tests. His passing gives a feeling of deep personal loss to his associates, and the memory of his warm genial spirit will be an inspiration to his friends.

Subcommittee V on Total Immersion Tests (F. N. Speller, chairman).—In the report of this subcommittee, appended hereto, considerable progress is reported in the sea-water immersion tests at Key West, Fla., Portsmouth, N. H., and Port Arthur, Tex. The investigation to determine whether consistent results can be obtained in testing iron and steel in 20-per-cent sulfuric acid, commonly called the "acid immersion test," by the procedure outlined in the report has been concluded. The results indicate that an acid test conducted as described is not capable of consistent repetition, and the data confirm the previous statements[1] of the committee that such a test does not forecast the relative life of ordinary ferrous materials in the atmosphere.

Subcommittee VI on Specifications for Metallic-Coated Products (F. F. Farnsworth, chairman).—This subcommittee has continued its study of wire and wire products and is reviewing specifications for galvanized steel pipe and conduit. A special committee, under the chairmanship of Mr. A. K. Graham, with Messrs. L. W. Hopkins, C. L. Hippensteel and T. C. Tweedie, is actively cooperating with the Research Committee of the American Electroplaters' Society in laying the ground work for the preparation of specifications for certain plated coatings on iron and steel which are of considerable public interest. It is anticipated that before specifications can be written considerable development work must be done on methods of testing plated coatings, evaluating the various types of coatings for particular exposures, and selecting plating solutions and methods best suited to produce coatings of known characteristics.

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[1] See 1928 Report of Committee A-5 on Corrosion of Iron and Steel, ***Proceedings***, Am. Soc. Testing Mats., Vol. 28, Part I, p. 150 (1928).

Subcommittee VII on Methods of Testing (E. S. Taylerson, chairman).—Subcommittee VII has been mostly concerned in determining the demand for new investigations and methods of testing. The research committee is still considering the possibility of developing a laboratory test which will predict service in the atmosphere. Its work is still confined to the simulated industrial atmospheric test, although the influence of salt spray is also under consideration. The apparatus employed is both elaborate and expensive and the program already under way will probably not be completed for several years. The progress to date has not been encouraging, though a large amount of work has been accomplished. The difficulty is not entirely due to design and operation of apparatus to enable consistent results to be obtained, but also involves the great variation in corrosion rate encountered in actual atmospheric exposure tests at different locations. It may be necessary to develop apparatus of a more flexible nature in which it will be possible to so vary the influence of a number of corroding agents as to duplicate a particular atmospheric condition. Very little is known of the essential differences in climate encountered in the field tests of Subcommittee VIII.

A special committee, under the chairmanship of Mr. L. W. Hopkins, has canvassed the demand by industry for methods of testing miscellaneous metallic coatings on iron and steel, and has submitted a report which indicates a strong desire for methods of determining the weight of coatings of nickel, copper, cadmium and chromium. A small group, under the chairmanship of Mr. C. L. Hippensteel, will study methods of determining the weight of such coatings. The demand for methods of determining the weight of lead, aluminum, and silver coatings was insufficient to justify extensive work, although known methods might be collected as information.

A committee under the chairmanship of Mr. F. M. Crapo is studying the present Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 – 30). An extensive comparative study has been made of the hydrochloric acid - antimony chloride and the dilute sulfuric acid methods which indicates excellent consistency. The difficulties in interpreting the Preece test for wire, hardware, and pipe has led to the appointment of a special committee under the chairmanship of Mr. C. C. Crane to study the specifications, limitations, and interpretation of the test.

Subcommittee VIII on Field Tests of Metallic Coatings (F. A. Hull, chairman).[1]—In the report of this subcommittee, appended hereto, the results of the inspections of the galvanized sheets, hardware, structural shapes, tubular goods, etc., on the test racks at Brunot Island, Pittsburgh, Pa.; Altoona, Pa.; State College, Pa.; Sandy Hook, N. J., and Key West, Fla., are reported. The results show a number of coating failures during the year. It is likely that all of the remaining coatings will soon show failure, but the test is to be continued until perforation of the base metal occurs. The light-coated ¾ to 1-oz. sheets at Sandy Hook commenced to show failures during the year. No failures have occurred at State College and Key West at the end of about 4½ years. The results of inspection of the hardware, structural shapes, tubular goods, etc., are given in detail. The metallic coatings on the specimens of hardware, structural shapes, tubular goods, etc., in these tests were furnished by a number of cooperating concerns, who were asked to apply metallic coatings representing their usual practice as to methods of application and weight. The data in Table V of the subcommittee's report should be interpreted in the light of the weights of metallic coatings shown by the determinations reported therein. Another series of tests is now being undertaken wherein the various coatings will be applied under defined conditions and of known and uniform thickness as representing the advancement in the art of electroplating. Specimens will be exposed on the test racks at Brunot Island, Pittsburgh, Pa.; State College, Pa.; Sandy Hook, N. J.; New York City; Washington, D. C.; and Key West, Fla.; and companion specimens will be used in laboratory stripping tests and accelerated exposures.

Subcommittee IX on Metal Culvert Tests (H. E. Smith, chairman).—This subcommittee has continued very careful discussion of the kinds of material which it is desirable to include in the proposed tests on metal culverts. An agreement has now been reached to include in the tests material made by galvanizing various kinds of base metal sheets. With this detail clarified, the subcommittee expects, during the present year, to perfect all details and have material ready for installation early in the spring of 1932.

Subcommittee X on Embrittlement Investigation (V. F. Hammel, chairman).—This subcommittee has made gratifying progress as indicated in the appended report. The question of steel embrittlement has provided more discussions than any other in the development of specifications for galvanized structural steel.

This committee is composed jointly of steel producers, galvanizers, fabricators and consumers, and in order that the work may be expedited, it has retained the Battelle Memorial Institute at Columbus, Ohio, to conduct research directed toward the explanation and solution of the problem. A small group under the chairmanship of Mr. J. J. Shuman, with Messrs. C. F. W. Rys, H. O. Hill, W. G. Kelley, V. F. Hammel, and C. S. Trewin, is acting as a steering committee for the work. The subject has in the past been one of controversy, due to lack of knowledge of the true causes of the trouble. The matter has now passed the point where any interest is inclined to fix the blame upon another without definite proof, all interests having harmoniously come to the conclusion that the facts should be sought. Hearty cooperation is being shown by all concerned.

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[1] Since its adoption at the annual meeting, this report has been slightly modified editorially respecting references to hardware, structural shapes, tubular goods, etc., in order to make clear that the tests refer to coatings and not to finished products.—ED.

At about the time this matter was under consideration by the committee, the Utilities Research Commission engaged the Battelle Memorial Institute on the same problem, and six months active work had been in progress when the committee's work was begun. The cooperation of the Utilities Research Commission has been secured, and the information developed by both investigations is available to each. No duplication will occur, the work of each augmenting that of the other. The purposes of the investigation are:

1. To determine the causes of embrittlement encountered in hot-dipped galvanized structural steel;

2. Depending upon the results of the research, to secure data as a basis for specifications for material or treatment suitable for hot-dip galvanizing;

3. To formulate practical shop tests for detecting embrittlement.

As brittle material is of rather infrequent occurrence, no samples of this material have been retained and are, therefore, not available for study. Accordingly, the work at Battelle Memorial Institute has been to review the literature, and then to study methods of test which could be used in specifications to prevent the inclusion of such a product in a commercial delivery. Further, through the cooperation of the rolling mills a field crew from the laboratory has been working in the mills, following the product through its successive steps, and testing the heats with the view to obtaining steel which exhibits the unsatisfactory characteristics. Since the start of the investigation no such material has been commercially encountered. Nevertheless, samples of these mill runs have been taken upon which laboratory studies are being made. These studies indicate conditions which might bring about embrittlement. So far, the ground work and certain fundamental indications have been established, but as yet no definite conclusions can be drawn as to the causes or their remedy. Decided progress has been made in the refinement of testing methods and in the development of new tests which bid fair to eliminate the personal equation which makes the present test, on which rejection for brittleness may be based, less satisfactory than it should be. The various factors that tend to throw the properties of the final product toward the tough or toward the brittle side are becoming more clear, and several different possible causes for brittleness have suggested themselves, each of which is being studied in detail.

This work is being financed by contributions from various sources which, up to the present time, amount to about $12,000. While these funds are sufficient to carry on the first year's work as contemplated, additional funds will be necessary to complete the project.

This report has been submitted to letter ballot of the committee, which consists of 114 members; 72 members returned their ballots, of whom 71 have voted affirmatively, and 1 negatively.

Respectfully submitted on behalf of the committee,

J. H. GIBBONEY,
Chairman.

JAMES ASTON,
Secretary.

Sea Water Immersion Tests:

The No. 22 gage sheets exposed March 1, 1927, in sea water, at Key West Navy Yard, showed up to March, 1931, a total of 126 failures out of 150 sheets originally in the test. A detailed record of the failures is given in Table I (Plate I). At Portsmouth, N. H., where the No. 22 gage sheets were exposed in sea water March 7, 1927, 149 failures out of 150 sheets in the test were recorded up to March, 1931, as shown in Table II (Plate II).

The No. 16 gage sheets exposed at Key West, Fla., March 1, 1927, showed a total of 11 failures out of 138 sheets in the test up to March, 1931, as shown in Table III. At Portsmouth, N. H., 7 failures of the No. 16 gage sheets have been recorded to date, DD-50 on December 4, 1929; HH-32 on February 5, 1930; OO-15 on March 1, 1930; CC-18 and DD-35 on May 1, 1930; YY-7 on January 5, 1931; and ZZ-420 on February 5, 1931. Inasmuch as so few failures have occurred, a table is not included at this time.

Riveted plates and copper-steel pipe immersed in sea water were inspected at Key West, Fla., January, 1931; at Portsmouth, N. H., March and September, 1930; and at Port Arthur, Tex., October, 1930. The riveted plates at Key West and Portsmouth were cleaned and copper replicas were made according to the method described in a paper by Mr. E. S. Taylerson presented before the Society in 1929.[1] Arrangements will be made to sand blast the riveted plates at Port Arthur and to make copper replicas of them as is being done annually at Portsmouth and Key West.

A progress report was submitted by Mr. James French in regard to the tests of rivets and plates on oil tankers. These tests are being conducted on the hulls of the S. S. New York, the M. S. Chester Sun, and the M. S. Pacific Sun. An inspection was made of the test of the S. S. New York in March, 1931, but no conclusions can be drawn at present.

Acid Immersion Tests:

The object of the acid immersion investigation was to determine whether consistent results can be obtained in testing iron and steel

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[1] E. S. Taylerson, "Method of Making Copper Replicas of Corroded Metal Objects," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 234 (1929).

Table I.—Report on Total Immersion Tests. Sheets Exposed March 1, 1927, in Sea Water at U. S. N

No. 22 Gage Sheets

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test												
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 16, 1928, 381 Days	Apr. 30, 1928. 427 Days	June 4, 1928, 462 Days	July 5, 1928, 493 Days	Sept. 7, 1928, 557 Days	Oct. 8, 1928, 588 Days	Nov. 7, 1928, 618 Days	Dec. 6, 1928, 647 Days	Jan. 7, 1929, 679 Days	Jan. 21, 1929,[a] 693 Days	Mar. 7, 1929, 738 Days	June 6, 1929, 829 Days
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.380	0.090	0.036		0.017	6		5					2					
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.062	0.405	0.100	0.043		0.014	6			1			2			1	1		
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.075	0.448	0.092	0.035		0.140	6			102		101			101		101, 102, 108		
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.041	0.372	0.094	0.067	0.010	0.254	6			6, 21, 23						30			
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.058	0.370	0.093	0.043		0.266	6										204		202, 202,
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.055	0.380	0.111	0.044		0.522	6										301		
B	Open-Hearth Steel	A	Non-Copper-Bearing	0.023	0.229	0.012	0.052	0.004	0.117	3										15		
F	Open-Hearth Steel	A	" " "	0.293	0.503	0.026	0.039	0.010	0.038	6			10						10			
O	Low-Copper Open-Hearth Steel	A	" " "	0.118	0.522	0.009	0.029	0.223	0.021	6	15, 17		16							9, 28		
Z4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.042	0.318	0.063	0.042		0.019	6	418		417, 418, 421									
B	Open-Hearth Steel	A	Copper-Bearing	0.038	0.232	0.009	0.063	0.004	0.167	3												
G	Open-Hearth Steel	A	" "	0.290	0.510	0.027	0.039	0.010	0.241	6				10								
H	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.076	0.371	0.011	0.028	0.002	0.246	6			11							8		
M	Open-Hearth Steel, Alan Wood Steel Co	B	" "	0.097	0.396	0.014	0.043	0.012	0.184	6					9							
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.078	0.322	0.010	0.020		0.237	6			2									
Z5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.067	0.351	0.045	0.052		0.187	6										501		
Z6	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.062	0.388	0.054	0.053		0.275	6			604									
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.012	0.027	0.003	0.022	0.002	0.021	6											13	
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.009	0.016	0.007	0.020	0.008	0.022	6												
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.010	0.065	0.007	0.026		0.033	6	3						1					
C	Copper-Bearing Pure Iron	A	Copper-Bearing	0.025	0.034	0.006	0.039	0.020	0.198	6										12		
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.016	0.075	0.009	0.034	0.003	0.269	6												
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.012	0.048	0.008	0.020		0.299	6							6					
K	Copper-Bearing Acid Open-Hearth Steel	A	" "	0.112	0.438	0.090	0.044	0.002	0.231	6	3	6								27		
E	Puddled Iron	A	Copper-Bearing	0.039	0.032	0.114	0.021	0.110	0.241	6							4					
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.052	0.146	0.021	0.213	0.019	6	5		3		1			4		2		
										150	6	2	14	1	3	1	4	2	3	14	1	3
	Total Failures to Date	....	....	......	......	......	......	......	......	....	6	8	22	23	26	27	31	33	36	50	51	54

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 1, 1927, IN SEA WATER AT U. S. NAV

No. 22 GAGE SHEETS

Average Analysis, per cent						Number of Sheets in Test	Fa											
Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 16, 1928, 381 Days	Apr. 30, 1928. 427 Days	June 4, 1928, 462 Days	July 5, 1928, 493 Days	Sept. 7, 1928, 557 Days	Oct. 8, 1928, 588 Days	Nov. 7, 1928, 618 Days	Dec. 6, 1928, 647 Days	Jan. 7, 1929, 679 Days	Jan. 21, 1929,[a] 693 Days	Mar. 7, 1929, 738 Days	June 6, 1929, 829 Days
0.038	0.380	0.090	0.036		0.017	6		5					2					
0.062	0.405	0.100	0.043		0.014	6			1			2			1	1		
0.075	0.448	0.092	0.035		0.140	6			102		101			101		101, 102, 108		
0.041	0.372	0.094	0.067	0.010	0.254	6			6, 21, 23						30			
0.058	0.370	0.093	0.043		0.266	6										204		202, 202, 204
0.055	0.380	0.111	0.044		0.522	6										301		
0.023	0.229	0.012	0.052	0.004	0.117	3										15		
0.293	0.503	0.026	0.039	0.010	0.038	6			10						10			
0.118	0.522	0.009	0.029	0.223	0.021	6	15, 17		16							9, 28		
0.042	0.318	0.063	0.042		0.019	6	418		417, 418, 421									
0.038	0.232	0.009	0.063	0.004	0.167	3												
0.290	0.510	0.027	0.039	0.010	0.241	6				10								
0.076	0.371	0.011	0.028	0.002	0.246	6			11							8		
0.097	0.396	0.014	0.043	0.012	0.184	6					9							
0.078	0.322	0.010	0.020		0.237	6			2									
0.067	0.351	0.045	0.052		0.187	6										501		
0.062	0.388	0.054	0.053		0.275	6			604									
0.012	0.027	0.003	0.022	0.002	0.021	6											13	
0.009	0.016	0.007	0.020	0.008	0.022	6												
0.010	0.065	0.007	0.026		0.033	6	3						1					
0.025	0.034	0.006	0.039	0.020	0.198	6										12		
0.016	0.075	0.009	0.034	0.003	0.269	6												
0.012	0.048	0.008	0.020		0.299	6							6					
0.112	0.438	0.090	0.044	0.002	0.231	6	3	6								27		
0.039	0.032	0.114	0.021	0.110	0.241	6							4					
0.030	0.052	0.146	0.021	0.213	0.019	6	5		3		1			4		2		
						150	6	2	14	1	3	1	4	2	3	14	1	3
……	……	……	……	……	……	….	6	8	22	23	26	27	31	33	36	50	51	54

PLATE I.
PROCEEDINGS, AM. SOC. TESTING MATS.
VOL. 31, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS

NAVAL STATION, KEY WEST, FLA.

Failures on Date of Inspections

	July 3, 1929, 856 Days	Aug. 7, 1929, 891 Days	Sept. 6, 1929, 921 Days	Oct. 7, 1929,[a] 952 Days	Nov. 7, 1929, 983 Days	Dec. 6, 1929, 1012 Days	Jan. 7, 1930, 1044 Days	Feb. 10, 1930 1078 Days	Mar. 7, 1930 1103 Days	Apr. 7, 1930 1134 Days	May 7, 1930 1164 Days	June 6, 1930 1194 Days	July 7, 1930 1225 Days	Aug. 7, 1930 1256 Days	Sept. 6, 1930 1286 Days	Oct. 7, 1930 1317 Days	Nov. 8, 1930 1349 Days	Dec. 8, 1930 1379 Days	Jan. 8, 1931,[a] 1410 Days
	20	3			4	2		22			7								
, 204		31 206 301				303				303		303		9 206			303		
		12 420										11				419		29	12
		16 501, 503, 504 605, 606, 606, 607		17 11 606	2 503		504			20		11 17		10, 11	12 1	13, 20	22, 24	9	14 18
		2	25				18	4			6						8		8
				8	15			6	18				14	30			20 15		6, 22
		2	12	8				10			6								
		6																	
	1	17	2	5	4	2	2	4	1	2	3	4	1	5	2	3	6	2	6
	55	72	74	79	83	85	87	91	92	94	97	101	102	107	109	112	118	120	126

TABLE II.—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 7, 1927, IN SEA W

No. 22 GAGE SHEETS

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test							
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Apr. 9, 1928, 399 Days	May 8, 1928, 428 Days	June 13, 1928, 464 Days	Jan. 4, 1929, 669 Days	Mar. 4, 1929, 728 Days	Apr. 6, 1929, 761 Days	May 1, 1929, 786 Days
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.380	0.094	0.042	0.007	0.012	6							
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.061	0.400	0.114	0.048		0.012	6							
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.071	0.393	0.089	0.045	0.009	0.135	6							108
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.041	0.382	0.098	0.068		0.250	6							
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.050	0.380	0.089	0.037	0.005	0.259	6							
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.041	0.365	0.095	0.045		0.518	6							
B	Open-Hearth Steel	A	Non-Copper-Bearing	0.110	0.380	0.016	0.065	0.013	0.082	4							
F	Open-Hearth Steel	A	" " "	0.293	0.503	0.026	0.039	0.010	0.038	6				11			10, 1
O	Low-Copper Open-Hearth Steel	A	" " "	0.142	0.545	0.007	0.027	0.217	0.015	6	30			33,34		32, 36	35
Z4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.100	0.319	0.069	0.044		0.018	6							
B	Open-Hearth Steel	A	Copper-Bearing	0.090	0.210	0.009	0.060	0.004	0.190	2							
G	Open-Hearth Steel	A	" "	0.290	0.510	0.027	0.039	0.010	0.241	6			10,11		12		
H	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.063	0.403	0.017	0.027	0.005	0.245	6	32	38	26	35			29
M	Open-Hearth Steel, Alan Wood Steel Co	B	" "	0.090	0.400	0.011	0.039		0.187	6			22	29,35	38		33
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.082	0.309	0.009	0.022		0.214	6				39		27	
Z5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.060	0.360	0.047	0.056		0.198	6							509
Z6	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.075	0.390	0.053	0.053	Trace	0.261	6					608		
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.033	0.025	0.004	0.020		0.025	6			33				
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.016	0.020	0.006	0.023		0.018	6				19			34
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.016	0.054	0.006	0.032		0.025	6						22	
C	Copper-Bearing Pure Iron	A	Copper-Bearing	0.032	0.025	0.005	0.030	0.006	0.178	6				32			
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.012	0.066	0.008	0.039		0.258	6						38	
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.017	0.048	0.006	0.021		0.302	6						39	
K	Copper-Bearing Acid Open-Hearth Steel	A	" "	0.102	0.455	0.087	0.045		0.238	6							
E	Puddled Iron	A	Copper-Bearing	0.024	0.034	0.111	0.022	0.146	0.297	6							
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.058	0.154	0.020	0.223	0.021	6							
										150	2	1	5	9	3	6	8
	Total Failures to Date										2	3	8	17	20	26	34

[a] All specimens in the inspection on these dates were sand blasted to facilitate inspection.

—REPORT ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 7, 1927, IN SEA WATER AT U. S. NAVY YARD,

No. 22 GAGE SHEETS

Average Analysis, per cent					Number of Sheets in Test											
Manganese	Phosphorus	Sulfur	Silicon	Copper		Apr. 9, 1928, 399 Days	May 8, 1928, 428 Days	June 13, 1928, 464 Days	Jan. 4, 1929, 669 Days	Mar. 4, 1929, 728 Days	Apr. 6, 1929, 761 Days	May 1, 1929, 786 Days	June 3, 1929,[a] 819 Days	July 9, 1929, 855 Days	Aug. 7, 1929, 884 Days	Sept. 5, 1929, 913 Days
0.380	0.094	0.042	0.007	0.012	6											
0.400	0.114	0.048		0.012	6											
0.393	0.089	0.045	0.009	0.135	6							108				
0 382	0 098	0.068		0.250	6											
0.380	0.089	0.037	0.005	0.259	6											207
0.365	0.095	0.045		0.518	6											
0 380	0.016	0.065	0 013	0.082	4								30			
0 503	0.026	0.039	0.010	0.038	6				11			10, 11				
0.545	0.007	0.027	0.217	0.015	6	30			33,34		32, 36	35				
0.319	0.069	0.044		0.018	6								424, 421			
0.210	0.009	0.060	0.004	0.190	2											25
0.510	0.027	0.039	0.010	0.241	6			10,11		12						
0.403	0.017	0.027	0.005	0.245	6	32	38	26	35			29				
0.400	0.011	0.039		0.187	6			22	29,35	38		33				26
0.309	0.009	0.C22		0.214	6				39		27		36			25
0.360	0.047	0.056		0.198	6							509				
0.390	0.053	0.053	Trace	0.261	6					608						
0.025	0.004	0.020		0.025	6			33					42	40		
0.020	0.006	0.023		0.018	6				19			34				21
0.054	0.006	0.032		0.025	6						22					
0.025	0.005	0.030	0.006	0 178	6				32				28		22	
0.066	0.008	0.039		0.258	6						38		33			
0.048	0.006	0.021		0.302	6						39					
0.455	0.087	0.045		0.238	6											
0.034	0.111	0.022	0.146	0.297	6										16	14
0.058	0.154	0.020	0 223	0.021	6								8			
					150	2	1	5	9	3	6	8	8	1	2	6
....	....	....	....	....	....	2	3	8	17	20	26	34	42	43	45	51

Plate II.
Proceedings, Am. Soc. Testing Mats.
Vol. 31, Part I.
Report of Committee A-5:
Total Immersion Tests.

D, PORTSMOUTH, N. H.

Failures on Date of Inspections															
Oct. 2, 1929, 940 Days	Nov. 4, 1929, 973 Days	Dec. 4, 1929,[a] 1003 Days	Jan. 6, 1930, 1036 Days	Feb. 5, 1930, 1066 Days	Mar. 1, 1930, 1090 Days	April 3, 1930, 1123 Days	May 1, 1930, 1151 Days	May 27, 1930, 1177 Days	July 30, 1930, 1241 Days	Aug. 22, 1930, 1264 Days	Sept. 11, 1930, 1284 Days	Oct. 15, 1930,[a] 1318 Days	Jan. 5, 1931, 1400 Days	Feb. 5, 1931, 1431 Days	Mar. 5, 1931, 1459 Days
	4	35 6	5	11	41	39 3 109, 109, 112		28			43 7	111, 113			45
306	33 213		308	36	39, 42 214	207	43		45 209	310	306		310	208 314	
	32, 38 422	36 10 423				12 424		422			12				
506 609	23 608	41 506	28	10 508		11 508	12	41	509	609		608	609		
37 25	31 30 30	41	32	36 35	33			39							
	24 29, 31 30	35 27, 37 33, 39	40	34 42 36				30				33 46		42	
	36	13, 22						20							
	6	7, 8, 9				7									
5	17	18	5	9	5	11	2	6	3	2	4	5	2	3	1
56	73	91	96	105	110	121	123	129	132	134	138	143	145	148	149

TABLE III.—REPORTS ON TOTAL IMMERSION TESTS. SHEETS EXPOSED MARCH 1, 1927, IN SEA WATER AT U. S. NAVAL STATION, KEY WEST, FLA.

NO. 16 GAGE SHEETS

Group	Designation	Series	Description	Average Analysis, per cent: Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper	Number of Sheets in Test	Failures on Date of Inspections: Sept. 6, 1929, 921 Days	Oct. 7, 1929,ᵃ 952 Days	Nov. 7, 1929, 983 Days	June 6, 1930, 1194 Days	Sept. 6, 1930, 1286 Days	Jan 8, 1931,ᵃ 1410 Days
AA	Bessemer Steel	A	Non-Copper-Bearing	0.030	0.420	0.085	0.040	0.003	0.012	6						
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.080	0.440	0.080	0.032		0.014	6		1				
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.060	0.360	0.091	0.066	0.005	0.254	6						
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.078	0.340	0.091	0.036		0.287	6						
BB	Open-Hearth Steel	A	Non-Copper-Bearing	0.058	0.359	0.022	0.049	0.005	0.109	6						
FF	Open-Hearth Steel	A	" " "	0.280	0.500	0.027	0.038	0.010	0.034	6						
OO	Low-Copper Open-Hearth Steel	A	" " "	0.110	0.360	0.008	0.029	trace	0.026	6			3			13
MM	Open-Hearth Steel, Alan Wood Steel Co	B	" " "	0.111	0.400	0.010	0.028	0.011	0.053	6						
ZZ4	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.047	0.389	0.040	0.027	0.007	0.033	6	418				417	
GG	Open-Hearth Steel	A	Copper-Bearing	0.290	0.510	0.028	0.039	0.010	0.217	6						
HH	Copper-Bearing Basic Open-Hearth Steel	A	" "	0.069	0.371	0.010	0.026	0.004	0.248	6						
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.087	0.330	0.009	0.019	0.008	0.239	6						
ZZ5	Copper-Bearing Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.075	0.390	0.070	0.073		0.257	6						
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.020	0.027	0.005	0.033	0.003	0.078	6						
DD	Low-Copper Pure Iron	A	" " "	0.019	0.025	0.004	0.027	0.003	0.028	6				24		
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.015	0.021	0.006	0.020	0.005	0.023	6		6				21
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.028	0.060	0.009	0.028	0.006	0.030	6		13	11			
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.018	0.028	0.005	0.032	0.006	0.262	6						
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.014	0.075	0.006	0.028	0.007	0.250	6						
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.009	0.050	0.008	0.018		0.288	6						
KK	Copper-Bearing Acid Open-Hearth Steel	A	" "	0.100	0.460	0.085	0.039		0.230	6						
EE	Puddled Iron	A	Copper-Bearing	0.033	0.026	0.111	0.019	0.109	0.307	6						
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.050	0.124	0.019	0.210	0.021	6						1
										138	1	3	2	1	1	3
	Total Failures to Date	...	...	...	...	...	...	...	...	...	1	4	6	7	8	11

ᵃ All specimens in the inspection on these dates were sand blasted to facilitate inspection.

sheets in 20-per-cent sulfuric acid and if the results in acid compare favorably with the results of corrosion tests in the atmosphere.

TABLE IV.—SUMMARY OF SULFURIC ACID (20-PER-CENT H_2SO_4 BY WEIGHT, 25° C.) TEST DATA, TIME OF PERFORATION IN HOURS OBTAINED BY FIVE LABORATORIES USING SIX SAMPLES NO. 22 GAGE, 1.5 BY 2.5 IN.

	Laboratory					Laboratory				
	A	B	C	D	E	A	B	C	D	E
	MATERIAL W[a], WROUGHT IRON					MATERIAL Y[a], OPEN-HEARTH STEEL				
Minimum	6	6	6	6	6	16	18	22	18	18
Maximum	8	8	8	7	6	21	20	23	21	24
Average of 6 tests	6.5	6.3	6.3	6.2	6.0	19.2	18.3	22.2	19.2	19.0
Average of 30 tests	6.3 hours					19.6 hours				
Range of 30 tests	6 to 8 hours					16 to 24 hours				
	MATERIAL S[a], OPEN-HEARTH STEEL					MATERIAL C[a], COPPER-BEARING OPEN-HEARTH STEEL				
Minimum	34	30	30	32	30	182	282	168	136	336
Maximum	40	33	41	35	42	273	307	168	156	336
Average of 6 tests	35.8	32.0	37.0	33.5	36.0	236	286	168	146	336
Average of 30 tests	34.9 hours					234 hours				
Range of 30 tests	30 to 42 hours					136 to 336 hours				
	MATERIAL K[a], COPPER-BEARING OPEN-HEARTH STEEL					MATERIAL V[a], OPEN-HEARTH IRON				
Minimum	206	282	168	157	336	302	307	289	317	336
Maximum	353	359	224	375	336	360	331	330	336	336
Average of 6 tests	288	304	211	243	336	341	315	307	326	336
Average of 30 tests	276 hours					325 hours				
Range of 30 tests	157 to 375 hours					289 to 360 hours				
	MATERIAL R[a], OPEN-HEARTH IRON					MATERIAL T[a], COPPER-BEARING OPEN-HEARTH IRON				
Minimum	497	473	400	417	504	450	622	336	336	504
Maximum	552	528	495	453	504	1319	960	712	478	1008
Average of 6 tests	514	498	445	436	504	892	735	511	385	784
Average of 30 tests	480 hours					661 hours				
Range of 30 tests	400 to 552 hours					336 to 1319 hours				
	MATERIAL U[a], OPEN-HEARTH IRON					MATERIAL N[a], COPPER-BEARING OPEN-HEARTH IRON				
Minimum	1176	622	545	336	840	1152	840	615	336	840
Maximum	1512	1122	1274	440	1344	1354	1193	1128	497	1176
Average of 6 tests	1362	918	942	393	1120	1268	1122	963	456	1036
Average of 30 tests	947 hours					969 hours				
Range of 30 tests	336 to 1512 hours					336 to 1354 hours				

[a] Letters refer to black sheets exposed at Brunot Island (Pittsburgh), Pa., and Key West, Fla., see *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, pp. 200, 201, 208, and 209 (1927).

The samples tested were sent to five laboratories and detailed instructions given to insure an exact procedure being followed in each case. The samples tested by the five cooperating laboratories were cut under the committee's jurisdiction from the remainder of two sheets of each material, part of which had been exposed in the atmospheric

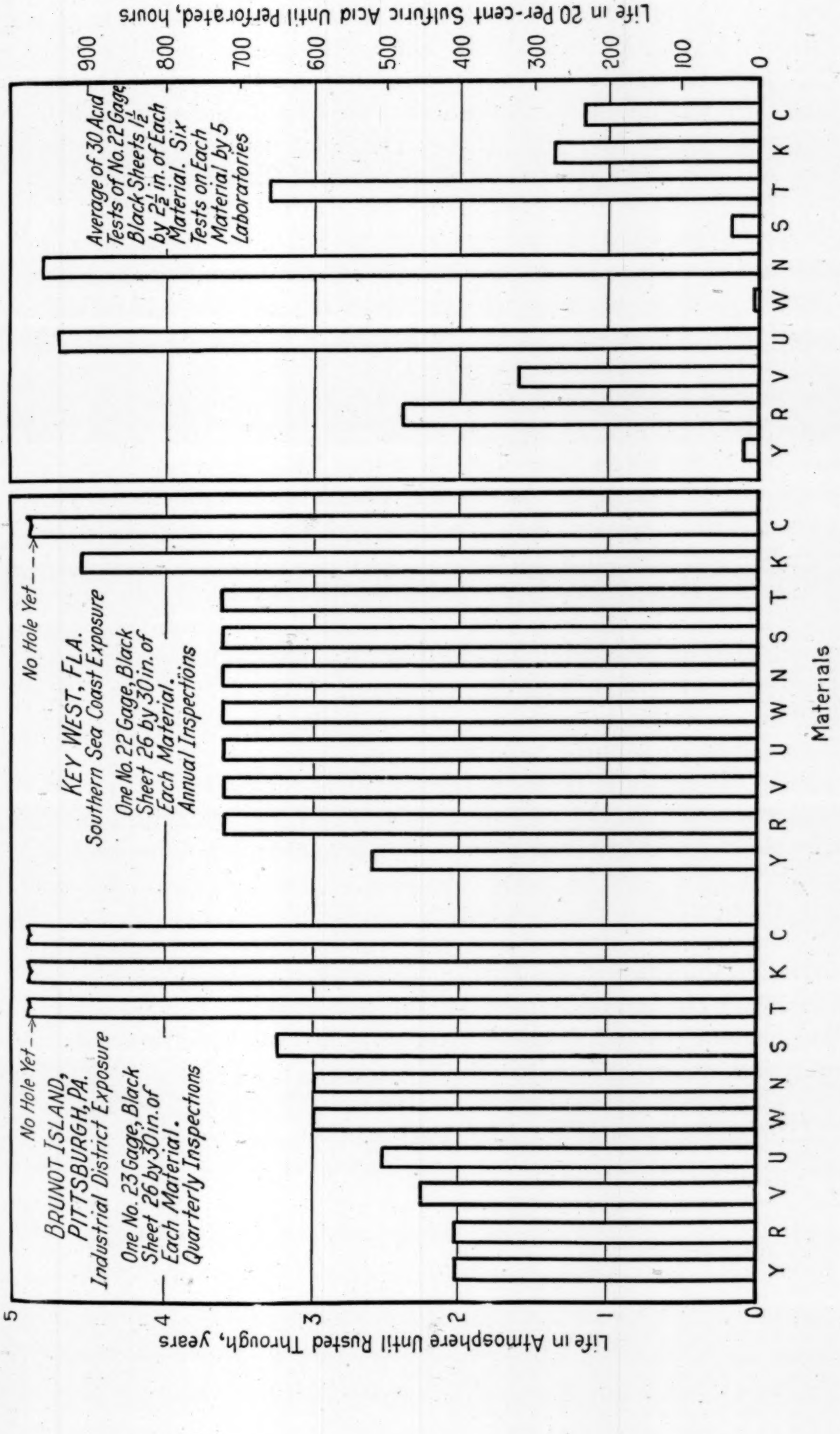

FIG. 1.—Comparison of Results of Corrosion Tests on Black Sheets in Atmosphere and in Sulfuric Acid.

tests of Subcommittee VIII on Field Tests of Metallic Coatings at Pittsburgh, Pa., and Key West, Fla. The samples were so sorted that each laboratory had a representative average set. The test procedure was originally outlined at a meeting of the subcommittee in Pittsburgh by Mr. J. T. Hay. The exact details of the method were unanimously approved by all members of the subcommittee.

The results from the various laboratories are shown in Table IV. As can be seen from an examination of these data the five laboratories obtained consistent results on only two of the ten materials tested. These two materials were wrought iron (*W*) and low-copper open-hearth steel (*S*) which had an average life of 6.3 and 34.9 hours, respectively, in 20-per-cent sulfuric acid. If the acid tests were a criterion of the life of ferrous materials under atmospheric conditions, the conclusion is that low-copper open-hearth steel is five and one-half times better than wrought iron. This, however, is neither borne out by experience, nor by the A.S.T.M. atmospheric corrosion tests at Pittsburgh and Key West which show no appreciable difference between these identical sheets.

In Fig. 1 graphs are shown comparing the life in acid of the various kinds of sheets in the tests with the life of similar sheets in the atmospheric tests at Pittsburgh and Key West. The materials, indicated by significant letters, have been arranged in the same order. The lack of correlation between the tests in 20-per-cent sulfuric acid and those in the atmosphere is obvious.

As the result of these experiments it is concluded that an acid test conducted by the procedure followed by the committee is not capable of consistent repetition. Further, the data from such an acid test should not be used to forecast the relative life of ordinary ferrous materials in the atmosphere.

Acknowledgment.—The subcommittee desires to express its appreciation to the Chief of the Bureau of Construction and Repair of the U. S. Navy Department for the valuable assistance and hearty cooperation rendered by the department in carrying out immersion tests in sea water.

This report was considered by the subcommittee at its meeting in Pittsburgh, Pa., on March 18, 1931, and was approved.

Respectfully submitted on behalf of the subcommittee,

F. N. SPELLER,
Chairman.

REPORT OF SUBCOMMITTEE VIII ON FIELD TESTS OF METALLIC COATINGS

Subcommittee VIII held one general meeting during the year. Its activities and investigations of the several materials now being studied are described below.

Galvanized Sheets

A Special Committee on Inspection of Galvanized Sheets under the chairmanship of Mr. M. E. McDonnell has made several inspections during the year.

The sheets on the test rack at Brunot Island, Pittsburgh, Pa., were inspected on April 21, July 28, and October 28, 1930, and on February 2, 1931. The sheets on the Altoona, Pa., test rack were inspected on April 22, July 29, and October 29, 1930, and on February 2, 1931. Inspections were made at Sandy Hook, N. J., on April 23 and October 30, 1930, and also at State College, Pa., on April 22 and October 29, 1930. The Key West, Fla., tests were inspected on January 6, 1931.

While corrosion has progressed, the general appearance of the sheets on all of the test racks is substantially the same as indicated in the report for 1930.[1] Tables I, II and III are for the sheets at Altoona, Brunot Island, and Sandy Hook, respectively, which had rusted at the time of the last inspection, together with the time of exposure when this condition was first observed.

From these tabulations it will be noted that the coatings on all of the sheets at Altoona have failed, with the exception of five 2½-oz. coatings on No. 22 gage sheets. The base metal has failed in the case of only one specimen of galvanized sheets, ¾ to 1-oz. coating, while in the case of the ungalvanized No. 22 gage black sheets four out of ten have failed.

At Brunot Island all of the ¾, 1¼, and 1½-oz. coatings, approximately 80 per cent of the 2-oz., and 20 per cent of the 2½-oz. coatings have failed. The base metal of two of the No. 28 gage, ¾ to 1-oz. coated sheets have failed due to fringing at the bottom edge. During the same interval, seven out of ten No. 22 gage uncoated black sheets failed.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 233 (1930).

TABLE I.—RECORD OF COATING FAILURES ON ALTOONA, PA., TEST RACK. SHEETS EXPOSED APRIL 22, 1926.

Description	Number of Samples in Test	Apr. 7, 1927, 0.96 year	Sept. 28, 1927, 1.43 years	May 1, 1928, 2.03 years	July 27, 1928, 2.27 years	Oct. 30, 1928, 2.53 years	Jan. 28, 1929, 2.77 years	Apr. 23, 1929, 3.00 years	July 23, 1929, 3.25 years	Oct. 29, 1929, 3.52 years	Feb. 10, 1930, 3.81 years	Apr. 22, 1930, 4.00 years	July 28, 1930, 4.27 years	Oct. 29, 1930, 4.52 years	Feb. 3, 1931, 4.79 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.	10	none	none	none	none	none	none	none	none	none	none	none	7	2	1	10	4.37
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	1	2	none	1	5	2	2	13	(4.40)[a]
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	none	none	none	none	6	4	none	none	8	..	..	18	(3.76)[a]
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	2	4	none	1	11	..	..	..	..	..	..	18	2.97
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	none	none	13	3	none	1	1	..	..	..	..	..	..	18	2.41
No. 22 Gage, 0.75 oz. per sq. ft.	14	none	6	1	7	..	..	..	..	..	..	..	..	..	..	14	1.89
No. 28 Gage, 0.75 oz. per sq. ft.	10	none	1	3	6	..	..	..	..	..	..	..	..	..	..	10	2.11
	106	none	7	4	28	7	none	2	19	6	none	1	20	4	3		
Total Failures to Date		none	7	11	39	46	46	48	67	73	73	74	94	98	101	101	

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[a] Figures shown in parentheses are not to be considered as final.

TABLE II.—RECORD OF COATING FAILURES ON BRUNOT ISLAND, PITTSBURGH, PA., TEST RACK. SHEETS EXPOSED APRIL 21, 1926.

Description	Number of Samples in Test	Apr. 6, 1927, 0.96 year	Sept. 27, 1927, 1.43 years	Apr. 30, 1928, 2.03 years	July 26, 1928, 2.27 years	Oct. 29, 1928, 2.53 years	Jan. 29, 1929, 2.78 years	Apr. 22, 1929, 3.00 years	July 22, 1929, 3.25 years	Oct. 28, 1929, 3.52 years	Feb. 11, 1930, 3.81 years	Apr. 21, 1930, 4.00 years	July 27, 1930, 4.27 years	Oct. 30, 1930, 4.52 years	Feb. 4, 1931, 4.79 years	Total Number of Failures	Average Life in Years
No. 16 Gage, 2.50 oz. per sq. ft.	12	none	none	none	none	none	none	none	none	none	none	none	1	none	2	3	(4.90)[a]
No. 22 Gage, 2.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	none	none	none	1	1	1	none	3	(4.88)[a]
No. 22 Gage, 2.00 oz. per sq. ft.	18	none	none	none	none	none	none	none	none	1	none	2	3	6	3	15	(4.49)[a]
No. 22 Gage, 1.50 oz. per sq. ft.	18	none	none	none	none	none	none	none	10	3	3	1	1	..	..	18	3.49
No. 22 Gage, 1.25 oz. per sq. ft.	18	none	none	none	none	2	none	none	16	..	..	..	..	..	..	18	3.17
No. 22 Gage, 0.75 oz. per sq. ft.	14	none	none	5	9	..	..	..	..	..	..	..	..	..	..	14	2.18
No. 28 Gage, 0.75 oz. per sq. ft.	10	none	none	2	8	..	..	..	..	..	..	..	..	..	..	10	2.22
	108	none	none	7	17	2	none	none	26	4	3	4	6	7	5		
Total Failures to Date	......	none	none	7	24	26	26	26	52	56	59	63	69	76	81	81	

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[a] Figures shown in parentheses are not to be considered as final.

At Sandy Hook the only coating failures were 60 per cent of the $\frac{3}{4}$ to 1-oz. coated sheets. In the same interval, at this location, one No. 22 gage uncoated black sheet has failed.

TABLE III.—RECORD OF COATING FAILURES ON SANDY HOOK, N. J., TEST RACK. SHEETS EXPOSED MAY 20, 1926.

DESCRIPTION	TOTAL NUMBER OF SAMPLES IN TEST	APRIL 24, 1930, INSPECTIONS 3.93 YEARS	OCT. 30, 1930, INSPECTIONS 4.45 YEARS	TOTAL NUMBER OF FAILURES	AVERAGE LIFE IN YEARS
No. 16 Gage, 2.50 oz. per sq. ft........	10	none	none	none	....
No. 22 Gage, 2.50 oz. per sq. ft........	18	none	none	none	....
No. 22 Gage, 2.00 oz. per sq. ft........	18	none	none	none	....
No. 22 Gage, 1.50 oz. per sq. ft........	18	none	none	none	....
No. 22 Gage, 1.25 oz. per sq. ft........	18	none	none	none	....
No. 22 Gage, 0.75 oz. per sq. ft........	14	none	10	10	(4.61)[a]
No. 28 Gage, 0.75 oz. per sq. ft........	10	none	6	6	(4.67)[a]
Total Failures to Date...........	106	none	16	16	

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[a] Figures shown in parentheses are not to be considered as final.

In Table IV, all black sheet failures which have developed at the five locations are reported in detail.

TABLE IV.—TIME IN YEARS FOR PERFORATIONS OF NO. 22 GAGE. BLACK SHEETS.[a]

Mark	Class of Material	Copper, per cent	Life in Atmosphere Until Rusted Through, years				
			Brunot Island, Pittsburgh, Pa.	Altoona, Pa.	Key West, Fla.	Sandy Hook, N. J.	State College, Pa.
R	Open-Hearth Iron................	0.03......	2.03	4.27	3.62	....	....
V	Open-Hearth Iron................	0.05......	2.27	4.27	3.62	....	....
U	Open-Hearth Iron................	0.09......	2.53	4.27	3.62	....	....
N	Copper-Bearing Open-Hearth Iron..	0.17......	3.00	....	3.62	....	....
T	Copper-Bearing Open-Hearth Iron..	0.23......	....	....	3.62	....	....
Y	Open-Hearth Steel................	0.03......	2.03	2.03	2.62	3.45	....
S	Open-Hearth Steel................	0.05......	3.25	....	3.62	....	....
C	Copper-Bearing Open-Hearth Steel..	0.22......	....	....	....	....	....
K	Copper-Bearing Open-Hearth Steel..	0.27......	....	....	4.58	....	....
W	Wrought Iron....................	0.02......	3.00	....	3.62	....	....

[a] Blanks in table represent sheets that have not failed as yet. The material has been under observation for $4\frac{1}{2}$ years.

HARDWARE, STRUCTURAL SHAPES TUBULAR GOODS, ETC.

A Special Committee on Inspection, under the chairmanship of Mr. W. L. Maucher, made two inspections during the year of the specimens on the test racks at Brunot Island, Altoona, Sandy Hook and State College, and one inspection at Key West. Diagrams showing the plan of installation and a description of the specimens on the test racks at the various locations are shown in Figs. 4 to

TABLE V.—REPORT ON INSPECTION OF METALLIC COATINGS ON HARDWARE,
RACKS AT FIVE

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base
a - in angle; < - less than; e - edges;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
3 BY 3 BY $\frac{5}{16}$-IN. PLAIN STEEL ANGLES									
Electro Galvanized	0.52	0	0	0	10Ra	0	<10R	15R	15R
		0	10Ra	25Ra	40R	0	0	15R	15R
		0	<10Ra	20Ra	30R	0	0	10R	15R
Hot Dip Galvanized	2.52	0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
Hot Dip Aluminum	0.89	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	0.09	90R	90R	95R	95R	100R	100R	100R	100R
		65R	90R	95R	95R	90R	100R	100R	100R
		50R	90R	95R	95R	100R	100R	100R	100R
Electric Sherardized	1.38	0	0	<10Re	<10Re	0	0	0d	100Y
		0	0	0	0	0	0	0d	100Y
		0	0	0	0	0	0	0d	100Y
Lead Plated	....	0	<10R*	<10R*	<10R*	0	0d	0d	<10R
		0	40R*	40R*	40R*	0	0d	0d	<10R
		0	20R*	20R*	20R*	0	0d	0d	<10R
3 BY 3 BY $\frac{5}{16}$-IN. COPPER-BEARING STEEL ANGLES									
Electro Galvanized	0.37	0	0	0	10R	0	<10Ra	20R	20R
		0	<10Ra	15Ra	60R	0	10Ra	20R	20R
		0	<10Ya	10Ya	15R	0	<10Ra	20R	20R
Hot Dip Galvanized	2.88	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.82	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	0.24	<10R	40Y - 50R	85R	95R	30Ra	80R	100R	100R
		<10R	40Y - 50R	85R	95R	75R	100R	100R	100R
		25R	25Y - 75R	90R	100R	15R	75R	100R	100R
Electric Sherardized	1.44	0	0	0d	0d	0	0d	0d	100Y
		0	0	0d	0d	0	0d	0d	100Y
		0	0	0d	0d	0	0d	0d	100Y
Lead Plated	....	<10R*	15R*	25R	50R	0	<10Y	10Yd	<10R
		0	15R*	20R	40R	0	0	0d	<10R
		<10R*	15R*	10R	40R	0	<10Y	10Yd	<10R
2 BY $1\frac{1}{2}$ BY $\frac{3}{16}$-IN. PLAIN STEEL ANGLES									
Electro Galvanized	0.53	0	<10Ra	40Ra	60R	0	20Ra	35Ra	40Ra
		0	20Ra	50Ra	70R	0	20Ra	30Ra	40Ra
		0	25Ra	40Ra	60R	0	20Ra	30Ra	40Ra
	0.50	0	0d	50Ya	40R	0	0	30Ya	40Ra
		0	0d	50Ya	40R	0	0	30Ya	40Ra
		0	0d	50Ya	50R	0	0	30Ya	40Ra
Hot Dip Galvanized	3.24	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.76	0	0	0d	0d	0	0	0d	0
		0	0	0d	0d	0	0	0d	0
		0	0	0d	0d	0	0	0d	0
Cadmium Plated	0.43	<10Y	50Ra	100R	100R	70R	95R	100R	100R
		25R	80R	100R	100R	50R	95R	100R	100R
		<10Y	90R	100R	100R	40R	95R	100R	100R
Electric Sherardized	1.21	<10Y	20Y	20Y	<10R	0	0d	10Y	<10R
		<10Y	20Y	20Y	<10R	0	0d	10Y	10Y
		<10Y	20Y	20Y	<10R	0	0d	10Y	10Y
Lead Plated	....	0	<10R*	<10R*	10R*	0	0	0	0
		0	<10R*	<10R*	10R*	0	0	0	0
		0	<10R*	<10R*	10R*	0	0	0	0

Structural Shapes, Tubular Goods, etc. Exposed to Atmosphere on Test Locations.

metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); th - threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
3 by 3 by $\frac{5}{16}$-in. Plain Steel Angles											
0	0	0	0	0	0	0	0	0	0	0.52	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	<10Y	<10Ra	0	0		
0	0	0	0	0	0	0	0	0	0	2.52	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.89	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
40R	50R	80R	80R	30Ra	75Ra	90R	95R	60R	75R	0.09	Cadmium Plated
20R	25R	65R	70R	30Ra	80Ra	90R	100R	<10R	<10R		
20R	20R	65R	70R	80R	90Ra	100R	100R	75R	75R		
0	0	0	0	0	0	0	0	0	<10Re	1.38	Electric Sherardized
0	0	0	0	0	0	0	0	0	<10Re		
0	0	0	0	0	0	0	0	0	<10Re		
0	10R	40R	40R	<10R	<10R	40R	50R	15R*	15R*	....	Lead Plated
0	15R	65R	65R	<10R	15R	50R	75R	15R*	15R*		
0	10R	30R	30R	<10R	15R	20R	40R	15R*	15R*		
3 by 3 by $\frac{5}{16}$-in. Copper-Bearing Steel Angles											
0	0	0	0	0	0	0	0	0	0	0.37	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	2.88	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	<10Y		
0	0	0	0	0	0	0	0	0	0	0.82	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	<10Ra	0	<10Y	10R	25R	0	0	0.24	Cadmium Plated
0	0	15R	15R	30R	60R	85R	90R	0	0		
0	0	<10R	<10R	0	<10R	10R	25R	<10R	10R		
0	0	0	10Y	0	0	0	0	<10Y	<10Re	1.44	Electric Sherardized
0	0	0	0	0	0	10Y	10Y	<10Y	<10Re		
0	0	0	10Y	0	0	0	0	<10Y	<10Re		
0	15R	75R	75R	<10R	40R	60R	90R	20R	20R	....	Lead Plated
0	<10R	10R	20R	<10R	25R	50R	80R	20R	20R		
0	<10R	50R	50R	<10R	20R	40R	50R	20R	20R		
2 by $1\frac{1}{2}$ by $\frac{3}{16}$-in. Plain Steel Angles											
0	0	10Y	<10Ra	0	0	0	0	0	0	0.53	Electro Galvanized
0	0	0	0	0	0	0	<10Ra	0	0		
0	0	0	0	0	0	<10Ra	10Ra	0	0		
0	0	0	0	0	0	0	0	0	0	0.50	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	3.24	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	15R	0	0	0.76	Hot Dip Aluminum
0	0	0	0	50R	70R	70R	70R	0	0		
0	0	0	0	0	<10R	20R	20R	<10Ra	<10Ra		
0	<10Ra	<10Ra	<10Ra	10Y	20Y	100Y	10R - 90Y	<10Ra	<10Ra	0.43	Cadmium Plated
0	<10Ra	<10Ra	10Ra	0	20Y	100Y	10R - 90Y	0	0		
0	<10Ra	<10Ra	20Ra	10Y	20Y	100Y	10R - 20Y	10R*	10R - 90Y		
0	20Y	60Y	100Y	0	0	0	<10Ra	10R*	15R - 85Y	1.21	Electric Sherardized
0	20Y	60Y	100Y	0	0	0	0	10R*	10R - 90Y		
0	20Y	60Y	100Y	0	0	0	0	10Re	10Re		
<10Re*	30R*	70R*	75R*	<10R	10R	10R	10R*	<10Re	<10Re	....	Lead Plated
<10Re*	<10R*	20R*	10R*	<10R	10R	10R	10R*	<10Re	<10Re		
<10Re*	20R*	50R*	30R*	<10R	15R	50R	50R*	...	...		

TABLE V.—REPORT ON INSPECTION OF

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base
a - in angle; < - less than; e - edges;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
		2 by $1\frac{1}{2}$ by $\frac{3}{16}$-in. Copper-Bearing Steel Angles							
Electro Galvanized	0.70	0	<10Y	30Ra	40Ra	0	20Ra	50Ra	75Ra
		0	20R	60Ra	70Ra	0	0	20Ra	30Ra
		0	0	30Ra	30Ra	0	10Ra	30Ra	40Ra
	0.76	0	0	0	0a	<10R	10Ra	10Ra	60Ra
		0	0	0	<10Ra	0	0	0	0
		<10R	20Ra	20Ra	20Ra	0	0	0	<10R
Hot Dip Galvanized	2.75	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.50	0	0	0d	0	0	0	0d	0d
		0	0	0d	0	0	0	0d	0d
		0	0	0d	0	0	0	0d	0d
Cadmium Plated	0.50	20R	80R	100R	100R	90R	90R	100R	100R
		25R	90R	100R	100R	40R	90R	100R	100R
		50R	95R	100R	100R	60R	90R	100R	100R
Electric Sherardized	1.15	0	20Y	60Y	0d	0	0d	0d	0d
		<10Y	20Y	60Y	0d	0	0d	0d	0d
		<10Y	20Y	60Y	10R	0	0d	0d	0d
Gas Sherardized	0.17	<10RY	95R	100R	100R	10R	100R	100R	100R
		<10RY	95R	100R	100R	60R	100R	100R	100R
		20R	95R	100R	100R	20R	100R	100R	100R
Lead Plated	....	0	<10R*	<10R*	<10R*	0	0	0	0d
		0	<10R*	<10R*	<10R*	0	0	0	0d
		0	<10R*	<10R*	<10R*	0	0	0	0d
		2-in. Diameter Tubular Goods							
Electro Galvanized	1.58	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
Hot Dip Galvanized	2.51	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
Hot Dip Aluminum	4.73	0	0	0d	0d	0	0d	0d	0d
		0	0	0d	0d	0	0d	0d	0d
		0	0	0d	0d	0	0d	0d	0d
Cadmium Plated	0.23	0	<10R	70R	100R	40R	90R	100R	100R
		<10R	40R	80R	100R	10R	90R	100R	100R
		<10R	30R	100R	100R	<10R	80R	100R	100R
	0.10	50R	90R	100R	100R	80R	95R	100R	100R
		15R	90R	100R	100R	30R	95R	100R	100R
		60R	90R	100R	100R	75R	95R	100R	100R
Electric Sherardized	0.29	0d	<10R	30R	100R	0d	<10R	20R	90R
		0d	<10R	10R	80R	0d	30R	40R	95R
		0d	<10R	10R	80R	0d	10R	30R	90R
	0.85	0d	<10R	10R	90R	0d	20R	40R	90R
		0d	<10R	30R	90R	0d	10R	20R	90R
		0d	<10R	40R	100R	0d	10R	25R	90R
Gas Sherardized	0.66	20Ys	0d	0d	0d	0	0d	0d	0d
		80Ys	0d	0d	0d	0	0d	0d	0d
		80Ys	0d	0d	0d	0	0d	0d	0d
Lead Plated	....	0	<10R*	<10R*	<10R*	0	0d	0d	0d
		0	<10R*	<10R*	<10R*	0	0d	0d	0d
		0	<10R*	<10R*	<10R*	0	0d	0d	0d

METALLIC COATINGS, ETC. (*Continued*).

metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
h - threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
2 BY $1\frac{1}{2}$ BY $\frac{3}{16}$-IN. COPPER-BEARING STEEL ANGLES											
0	0	0	0	0	0	0	...	0	0	0.70	Electro Galvanized
0	0	0	0	0	0	0	...	0	0		
0	0	0	0	0	0	0	...	0	0		
0	0	0	0	0	<10Ra	<10Ra	...	0	0	0.76	
0	0	0	0	<10Ra	<10Ra	<10Ra	...	<10Ra	<10Ra		
<10R	<10Ra	<10Ra	<10Ra	0	0	0d	...	0	0		
0	0	0	0	0	0	0	...	0	0	2.75	Hot Dip Galvanized
0	0	0	0	0	0	0	...	0	0		
0	0	0	0	0	0	0	...	0	0		
0	0	0	0	0	0	0	...	0	0	0.50	Hot Dip Aluminum
0	0	0	0	0	0	0	...	0	0		
0	0	0	0	0	0	0	...	0	0		
0	0	0	0	0	10Ra	20Ra	...	15Ra	15Ra	0.50	Cadmium Plated
0	<10Ra	<10Ra	<10Ra	0	10Ra	30Ra	...	0	<10R		
0	0	0	0	0	10Ra	20Ra	...	<10Re	<10R		
100Y	30R - 70Y	100R	100R	0	100Y	100Y	...	100R	100R	1.15	Electric Sherardized
100Y	50R - 50Y	100R	100R	15Y	100Y	100Y	...	100R	100R		
100Y	70R - 30Y	100R	100R	20Y	100Y	100Y	...	100R	100R		
...	...	...	...	100Y	100R	100R	...	100R	100R	0.17	Gas Sherardized
...	...	...	...	100Y	100R	100R	...	100R	100R		
...	...	...	...	100Y	100R	100R	...	100R	100R		
<10Re	20R	40R	60R	<10R*	<10R*	10R*	...	10R	10R	0.17	Lead Plated
<10Re	10R	20R	30R	<10R*	15R*	20R*	...	10R	10R		
<10Re	10R	15R	30R	<10R*	<10R*	10R*	...	<10R	<10R		
2-IN. DIAMETER TUBULAR GOODS											
0	0	0	0	0	0	0	0	0	0	1.58	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	2.51	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	4.73	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	<10R	<10R	0	<10R	0.23	Cadmium Plated
0	0	0	0	0	<10R	10R	30R	0	<10R		
0	0	0	0	0	<10R	<10R	<10R	0	<10R		
0	0	<10R	<10R	0	10R	20R	45R	<10R	<10R	0.10	
0	0	0	0	0	10R - 90Y	80R	90R	0	<10R		
0	0	<10Y	<10R	0	10R - 90Y	70R	90R	<10R	<10R		
0	0	<10Y	<10R	<10Y	50Y	80Y	40R	10Y	50Y	0.29	Electric Sherardized
0	0	<10Y	<10R	<10Y	50Y	80Y	10R	10Y	50Y		
0	0	0	0	<10Y	50Y	80Y	10R	10Y	50Y		
0	0	0	0	<10Y	50Y	100Y	45R	50Y	75Y	0.85	
0	0	0	0	<10Y	50Y	100Y	20R	50Y	75Y		
0	0	0	0	<10Y	50Y	100Y	30R	50Y	75Y		
0	0	0	0	10Y*	80Y	100Y	100Y	40Y	75Y	0.66	Gas Sherardized
0	0	0	0	<10Y*	80Y	100Y	100Y	40Y	40Y		
0	0	0	0	10Y*	80Y	100Y	100Y	40Y	50Y		
10R*	20R*	20R*	50R*	<10R*	<10R*	10R*	15R*	<10R	<10R	0.66	Lead Plated
10R*	15R*	20R*	30R*	<10R*	<10R*	<10R*	10R*	<10R	<10R		
10R*	20R*	30R*	60R*	<10R*	<10R*	<10R*	<10R*	<10R	15R		

TABLE V—REPORT ON INSPECTION OF

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base
a - in angle; < - less than; e - edges;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
						1-IN. DIAMETER TUBULAR GOODS			
Electro Galvanized	1.62	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized	1.83	0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
Hot Dip Aluminum	1.83	0	0	0	0d	0	0d	0d	0d
		0	0	0	0d	0	0d	0d	0d
		0	0	0	0d	0	0d	0d	0d
Cadmium Plated	0.30	95R	100R	100R	100R	95R	100R	100R	100R
		<10R	15R	70R	100R	<10R	60R	80R	100R
		60R	100R	100R	100R	<10R	100R	100R	100R
	0.18	0	<10R	30R	90R	<10R	30R	50R	100R
		20R	30R	40R	95R	<10R	30R	50R	100R
		<10R	20R	30R	95R	<10R	30R	50R	100R
Electric Sherardized	0.42	<10Rd	100R	100R	100R	<10R	50R	60R	90R
		0d	<10R	20R	95R	90R	100R	100R	100R
		0d	<10R	10R	95R	80R	100R	100R	100R
	0.92	0d	0d	0d	0d	0	0d	0d	<10R
		0d	0d	0d	0d	0	0d	0d	0d
		0d	0d	0d	0d	0	0d	0d	0d
Gas Sherardized	0.72	100Ys	25Ys	0d	0d	0	0d	0d	0d
		100Ys	25Ys	0d	0d	0	0d	0d	0d
		100Ys	25Ys	0d	0d	0	0d	0d	0d
Calorized	....	100Ys	50Ys	0d	0d	0	0d	0d	0d
		100Ys	50Ys	0d	0d	0	0d	0d	0d
		100Ys	50Ys	0d	0d	0	0d	0d	0d
Lead Plated	....	100Y	<10R	<10R*	<10R*	0	0d	0d	0d
		100Y	<10R	<10R*	<10R*	0	0d	0d	0d
		100Y	<10R	<10R*	<10R*	0	0d	0d	0d
Amaloy	....	100Y	10R*	10R*	10R*	0	0	0	0
		100Y	10R*	20R*	25R*	0	0	0	0
		100Y	10R*	10R*	20R*	0	0	0	0
						FORGED STEEL TOWER FITTING			
Electro Galvanized	Bolt 0.31	0	0	<10Y	<10R	0	0	<10R	<10R
	Nut 0.54	0	0	<10Y	<10R	0	0	0	<10R
	Clamp 1.15	0	0	<10Y	<10R	0	0	10R	15R
	Bolt 0.02	0	0	10R	40R	0	<10R	20R	60R
	Nut 0.01	0	<10Y	30Y	50R	0	<10Y	10R	35R
	Clamp 0.46	0	0	<10Y	<10R	Pin 100R	20R	30R	60R
Hot Dip Galvanized	2.67	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
	1.53	0	0	0	0	0	0	0d	40Y
		0	0	0	0	0	0	0d	40Y
		0	0	0	0	0	0	0d	40Y
Hot Dip Aluminum	....	0	0	0d	0d	0	0	0	0
		0	0	0d	0d	0	0	0	0
		0	0	0d	0d	0	0	0	0
Cadmium Plated	1.40	0	<10Y	50R	95R	<10R	10R	40R	85R
		<10R	25R	90R	100R	<10R	60R	80R	100R
		...	...	...	...	10R	...	...	...
Electric Sherardized	0.50	0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
Gas Sherardized	....	80Ys	<10Ys	0	50R	100Ys	10Ys	0	0d
		60Ys	<10Ys	0	0	100Ys	10Ys	0	0d
		60Ys	<10Ys	0	<10R	100Ys	10Ys	0	0d
Parkerized	0.26	<10R	<10R	10R	10R	0	<10R	10R	10R
		0	<10R	10R	30R	0	<10R	<10R	<10R
		0	<10R	<10R	20R	0	<10R	<10R	10R
Cadmium Plated	....	<10R	75R	100R	100R	10R	90R	100R	100R
		0	90R	100R	100R	10R	90R	100R	100R
		<10R	40R	50R	100R	10R	90R	100R	100R
Lead Plated	0.31	50R	100R	100R	100R	90R	100R	100R	100R
		15R	100R	100R	100R	90R	100R	100R	100R
		70R	100R	100R	100R	90R	100R	100R	100R

* Specimens blown down, rack damaged.

Metallic Coatings, etc. (*Continued*).

metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt)
th - threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	96 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
1-in. Diameter Tubular Goods											
0	0	0	0	0	0	0	0	0	0	1.62	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.83	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.83	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
<10R	10R	10R	20R	0	0	<10R	a	20R	30R	0.30	Cadmium Plated
<10R	30R	50R	60R	0	<10R	<10R	a	35R	60R		
<10R	<10R	<10R	20R	40R	90R	100R	a	25R	60R		
0	0	<10R	<10R	0	0	a	a	0	0	0.18	
0	0	0	0	<10R	20R	a	a	0	0		
<10R	20R	20R	30R	0	0	a	a	0	0		
0d	0	0	0	<10Y	90Y	a	a	25Y	25Y	0.42	Electric Sherardized
0d	50Y	10R	80R	<10Y	<10R	a	a	75Y	50R - 50Y		
0d	50Y	10R	80R	40Y	50R	a	a	80Y	50R - 50Y		
0	0	0	0	10Y	90Y	a	a	<10Y	<10Y	0.92	
0	0	0	0	10Y	90Y	a	a	<10Y	<10Y		
0	0	0	0	10Y	90Y	a	a	<10Y	<10Y		
0	0	0	0	20Y	100Y	a	a	100Y	100Y	0.72	Gas Sherardized
0	0	0	0	20Y	100Y	a	a	100Y	100Y		
0	0	0	0	20Y	100Y	a	a	100Y	100Y		
<10R*	<10R*	<10R*	<10R*	50Y	10R	a	a	25R	30R	0.72	Calorized
<10R*	<10R*	<10R*	<10R*	50Y	10R	a	a	25R	30R		
<10R*	<10R*	<10R*	<10R*	50Y	10R	a	a	25R	30R		
0	<10R*	10R	15R	<10R	<10R*	a	a	<10R	<10R	0.72	Lead Plated
0	<10R*	10R	15R	<10R	<10R*	a	a	<10R	10R		
0	<10R*	10R	15R	<10R	<10R*	a	a	<10R	<10R		
20R*	60R	70R	80R	<10R	30R	a	a	10R	10R	0.72	Amaloy
20R*	50R	70R	80R	<10R	50R	a	a	10R	10R		
0	0	0	0	<10R	25R	a	a	0d	0d		
Forged Steel Tower Fitting											
0	0	0	0	0	0	0	0	0	0	Bolt 0.31	Electro Galvanized
0	0	0	0	0	0	0	0	0	0	Nut 0.54	
0	0	0	0	0	0	0	0	0	0	Clamp 1.15	
0	0	0	0	0	0	10Y	100Y	0	0	Bolt 0.02	
0	0	0	0	0	0	10Y	100Y	0	0	Nut 0.01	
0	0	0	0	0	0	10Y	100Y	0	0	Clamp 0.46	
0	0	0	0	0	0	0	0	0	0	2.67	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.53	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	<10R	<10R	....	Hot Dip Aluminum
0	0	0	0	0	0	0	0	<10R	<10R		
0	0	0	0	0	0	0	0	<10R	<10R		
0	0	0	0	0	<10R	<10R	<10R	<10R	10R	1.40	Cadmium Plated
0	0	<10R	<10R	0	<10R	<10R	<10R	<10R	10R		
0	0	<10R	<10R	0	<10R	<10R	<10R	...	...		
0	0	0	0	0	0	0	0	0	0	0.50	Electric Sherardized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
10Y	50Y	80Y	100Y	30Y	50Y	100Y	100Y	20R*	20R - 80Y	....	Gas Sherardized
10Y	75Y	80Y	100Y	<10Y	50Y	100Y	100Y	10R*	10R - 90Y		
10Y	75Y	80Y	100Y	10Y	50Y	100Y	100Y	10R*	10R - 90Y		
0	20R	40R	70R	<10R	20R	20R	40R	100R	100R	0.26	Parkerized
0	20R	40R	70R	<10R	70R	90R	100R	100R	100R		
0	20R	40R	70R	<10R	50R	60R	60R	100R	100R		
0	0	0	0	0	0	0	10R - 90Y	<10R	<10R	....	Cadmium Plated
0	0	0	0	0	0	0	10R - 90Y	<10R	<10R		
0	0	0	0	0	0	0	10R - 90Y	<10R	<10R		
100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	0.31	Lead Plated
100R	100R	100R	100R	100R	100R	100R	100R	100R	100R		
100R	100R	100R	100R	100R	100R	100R	100R	100R	100R		

TABLE V.—REPORT ON INSPECTION OF

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of base
a - in angle; < - less than; e - edges;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
						¾-IN. NIPPLES AND ELLS			
Electro Galvanized Malleable Iron........	Nipple 1.68	0	0	<10Y	<10R	0	0	0	0
	Nipple 1.61	0	0	0	0	0	0	0	0
	Ell 1.55	0	0	<10Y	<10R	0	0	0	0
Electro Galvanized Cast Iron.............	....	0	0	<10R	<10R	0	0	0	0
	Nipple 2.02	0	0	0	0	0	0	0	0
	Ell 2.36	0	0	0	0	0	0	0	0
Electro Galvanized Malleable Iron........	Nipple 1.96	0	0	0	<10R	0	0	0	0
	Nipple 2.43	0	0	<10R	<10R	0	0	10Y	10Y
	Ell 2.90	0	0	10R	15R	0	0	10Y	10Y
Electro Galvanized Cast Iron.............	....	0	0	0	<10R	0	0	0	0
	Nipple 1.82	0	0	10R	25R	0	0	10R	15R
	Ell 0.67	0	0	0	<10R	0	0	0	15R
Hot Dip Galvanized Malleable Iron........	1.82	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized Cast Iron.............	1.44	0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0	0d
Hot Dip Aluminum Malleable Iron........	3.20	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth
		0	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth
		0	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth
Hot Dip Aluminum Cast Iron.............	2.80	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth
		<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth
		<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	10Rth
Cadmium Plated Malleable Iron........	....	<10R	100R	100R	100R	20R	100R	100R	100R
		<10R	100R	100R	100R	20R	90R	100R	100R
		<10R	100R	100R	100R	20R	[illegible]	100R	100R
Cadmium Plated Cast Iron.............	....	<10R	100R	100R	100R	30R	100R	100R	100R
		<10R	100R	100R	100R	30R	100R	100R	100R
		15R	100R	100R	100R	30R	100R	100R	100R
Cadmium Plated Malleable Iron........	....	0	0	0d	0d	20R	100R	100R	100R
		0	0	0d	0d	20R	80R	100R	100R
		0	0	0d	0d	20R	95R	100R	100R
Cadmium Plated Cast Iron.............	....	<10Ys	<10Ys	0d	0d	50R	100R	100R	100R
		<10Ys	<10Ys	0d	0d	30R	100R	100R	100R
		<10Ys	<10Ys	0d	0d	40R	100R	100R	100R
Electric Sherardized Malleable Iron........	0.63	15Ys	10Y	10Y	10R	0	0	0	0d
		10Ys	10Y	10Y	10Y	0	0	0	0d
		40Ys	10Y	10Y	10Y	0	0	0	0d
Electric Sherardized Cast Iron.............	0.47	40Ys	10Y	100Y	<10R	0	0d	0d	0d
		40Ys	10Y	100Y	60R	20Ys	0d	0d	0d
		40Ys	10Y	100Y	60R	10Ys	0d	0d	0d
Gas Sherardized Malleable Iron........	0.78	0	<10R*	10R*	15R*	100Ys	0d	0d	40R
		0	<10R*	10R*	10R*	100Ys	0d	0d	0d
		0	<10R*	10R*	10R*	100Ys	0d	0d	10R
Gas Sherardized Cast Iron.............	0.84	0	<10R*	0d	<10R	100Ys	0d	0d	10R
		0	<10R*	0d	<10R	100Ys	0d	0d	30R
		0	<10R*	0d	<10R	100Ys	0d	0d	0d
Parkerized Malleable Iron........	....	0	0	0	0	0	0	<10R	<10R
		0	0	0	0	0	0	<10R	<10R
		0	0	0	0	0	0	<10R	<10R
Parkerized Cast Iron...	....	<10R	0	0	0	0	0	<10R	<10R
		0	0	0	0	0	0	<10R	<10R
		0	0	0	0	0	0	<10R	<10R
Electric Sherardized Malleable Iron........	0.75	<10R	10R	10R	15R	0	0	0	0
		<10R	10R	10R	15R	0	0	0	0
		<10R	20R	40R	40R	0	0	0	0
Electric Sherardized Cast Iron.............	0.82	0	<10R	10R	25R	0	0	0	0
		<10R	10R	20R	30R	0	0	0	0
		<10R	10R	10R	20R	0	0	0	0
Amaloy Malleable Iron.	....	...	...	...	...	0	0	0	0
		...	...	...	...	0	0	0	0
		...	...	...	...	0	0	0	0
Amaloy Cast Iron......	....	...	...	...	...	0	0	0	0
		...	...	...	...	0	0	0	0
		...	...	...	...	0	0	0	0

METALLIC COATINGS, ETC. (*Continued*).

metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
th - threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
$\frac{3}{4}$-IN. NIPPLES AND ELLS											
0	0	0	0	0	0	0	0	0	0	Nipple 1.68	Electro Galvanized Malleable Iron
0	0	0	0	0	0	0	0	0	0	Nipple 1.61	
0	0	0	0	0	0	0	0	0	0	Ell 1.55	
0	0	0	0	0	0	0	0	0	0	....	Electro Galvanized Cast Iron
0	0	0	0	0	0	0	0	0	0	Nipple 2.02	
0	0	0	0	0	0	0	0	0	0	Ell 2.36	
0	0	0	0	0	0	0	0	0	0	Nipple 1.96	Electro Galvanized Malleable Iron
0	0	0	0	0	0	0	0	0	0	Nipple 2.43	
0	0	0	0	0	0	0	0	0	0	Ell 2.90	
0	0	0	0	0	0	0	0	0	0	....	Electro Galvanized Cast Iron
0	0	0	0	0	0	0	0	0	0	Nipple 1.82	
0	0	0	0	0	0	0	0	0	0	Ell 1.67	
0	0	0	0	0	0	0	0	0	0	1.82	Hot Dip Galvanized Malleable Iron
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.44	Hot Dip Galvanized Cast Iron
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
<10Rth	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	15Rth	10Rth	25Rth	3.20	Hot Dip Aluminum Malleable Iron
<10Rth	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	20Rth	10Rth	25Rth		
<10Rth	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	15Rth	10Rth	25Rth		
<10Rth	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	15Rth	10Rth	25Rth	2.80	Hot Dip Aluminum Cast Iron
<10Rth	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	15Rth	10Rth	25Rth		
<10Rth	<10Rth	10Rth	10Rth	10Rth	10Rth	10Rth	15Rth	10Rth	25Rth		
0	0	0	0	0	<10Y	10Y	25R	0	<10R	....	Cadmium Plated Malleable Iron
0	0	0	0	0	<10Y	10Y	25R	0	0		
0	0	0	0	0	<10Y	10Y	25R	0	<10R		
0	0	0	0	0	<10Y	20Y	50R	0	0	....	Cadmium Plated Cast Iron
0	0	0	0	0	<10Y	20Y	50R	0	0		
0	0	0	0	0	<10Y	20Y	50R	0	0		
0	0	0	0	0	<10Y	10Y	25R	0	0	....	Cadmium Plated Malleable Iron
0	0	0	0	0	<10Y	10Y	25R	0	0		
0	0	0	0	0	<10Y	10Y	25R	0	0		
0	0	0	0	0	<10Y	100Y	60R	0	0	....	Cadmium Plated Cast Iron
0	0	0	0	0	<10Y	100Y	60R	0	0		
0	0	0	0	0	<10Y	100Y	60R	0	0		
0	0	0	0	<10Y	10Y	100Y	100Y	<10R	<10R	0.63	Electric Sherardized Malleable Iron
0	0	0	0	<10R	10Y	100Y	100Y	10Y	10Y		
0	0	0	0	<10Y	10Y	100Y	100Y	10Y	10Y		
0	0	0	0	0	10Y	100Y	100Y	10Y	10Y	0.47	Electric Sherardized Cast Iron
0	0	0	0	0	10Y	100Y	100Y	10Y	<10R		
0	0	0	0	0	10Y	100Y	100Y	10Y	<10R		
0	0	0	0	10Y	100Ys	100Y	100Y	10R*	40R	0.78	Gas Sherardized Malleable Iron
0	0	0	0	10Y	100Ys	100Y	100Y	10R*	50R		
0	0	0	0	10Y	100Ys	100Y	100Y	10R*	30R		
0	0	0	100Y	10Y	10R – 90Y	20R – 80Y	40R	10R*	60R	0.84	Gas Sherardized Cast Iron
0	<10R	40 or R	40R	10Y	100Y	100Y	40R	10R*	20R		
0	10Y	100Y	100Y	10Y	100Y	100Y	40R	10R*	20R		
0	<10R	20R	25R*	0	0d	0d	<10R	40R	50R	....	Parkerized Malleable Iron
0	<10R	20R	25R*	0	0d	<10R	10R	40R	50R		
0	0d	0d	25R*	0	0d	<10R	15R	40R	50R		
0	0d	0d	25R*	0	0d	<10R	<10R	40R	50R	....	Parkerized Cast Iron
0	0	<10R	25R*	0	0d	<10R	<10R	40R	50R		
0	0	10R	25R*	0	<10R	<10R	<10R	40R	50R		
0	0	0	0	0	0	0	0	<10Y	<10R	0.75	Electric Sherardized Malleable Iron
0	0	0	0	0	0	0	0	<10Y	<10R		
0	0	0	0	0	0	0	0	<10Y	10Y		
0	0	0	0	0	0	0	0	...	...	0.82	Electric Sherardized Cast Iron
0	0	0	0	0	0	0	0	...	...		
0	0	0	0	0	0	0	0	...	...		
30R	60R	70R	75R	15R	30R	50R	50R	20R	25R	....	Amaloy Malleable Iron
30R	60R	70R	75R	15R	30R	50R	50R	20R	25R		
30R	60R	70R	75R	20R	30R	50R	50R	20R	25R		
30R	50R	60R	75R	20R	30R	40R	40R	30R	30R	....	Amaloy Cast Iron
30R	50R	60R	75R	15R	30R	40R	40R	30R	30R		
40R	50R	60R	75R	15R	30R	40R	40R	30R	30R		

TABLE V.—REPORT ON INSPECTION O

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of ba
a - in angle; < - less than; e - edg

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Week
						TOWER CLAMPS			
Electro Galvanized Malleable Iron	Bolt 0.31	0	0	0	0	0	0	<10Y	<10
	Nut 0.54	0	0	0	0	0	0	0	0
	Clamp 1.15	0	0	<10R	10R	0	0	0	10
Electro Galvanized Cast Iron	Bolt 0.28	0	0	0	0	0	0	<10Y	10
	Nut 0.56	0	0	0	<10R	0	0	<10Y	10
	Bolt 0.90	0	0	0	<10R	0	0	10Y	10
Electro Galvanized Malleable Iron	Bolt 0.02	0	<10Y	30R	90R	0 10R stud	20R	30R	30
	Nut 0.01	0	0	0	40R	0 10R stud	20R	30R	60
	Clamp 0.46	0	0	0	0	0 10R stud	20R	30R	60
Electro Galvanized Cast Iron	Bolt 0.04	0	0	10Y	<10R	0 10R stud	20R	40R	60
	Nut 0.04	0	0	20Y	15R	0 10R stud	20R	60R	60
	Clamp 0.74	0	0	<10Y	25R	0 10R stud	20R	40R	40
Hot Dip Galvanized Malleable Iron	1.53	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized Cast Iron	1.75	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized Malleable Iron	2.00	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized Cast Iron	2.38	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Cadmium Plated Malleable Iron	0.28	15R	100R	100R	100R	<10R	90R	100R	100
		<10R	100R	100R	100R	<10R	90R	100R	100
		<10R	100R	100R	100R	<10R	90R	100R	100
Cadmium Plated Cast Iron	0.28	10R	100R	100R	100R	80R	90R	100R	100
		10R	100R	100R	100R	80R	90R	100R	100
		10R	100R	100R	100R	80R	90R	100R	100
Cadmium Plated Malleable Iron	0.15	100R	100R	100R	100R	100R	90R	100R	100
		100R	100R	100R	100R	100R	90R	100R	100
		100R	100R	100R	100R	100R	90R	100R	100
Cadmium Plated Cast Iron	0.17	100R	100R	100R	100R	100R	90R	100R	100
		100R	100R	100R	100R	100R	90R	100R	100
		100R	100R	100R	100R	100R	90R	100R	100
Electric Sherardized Malleable Iron	1.75	30R	100R	100R	100R	90Y	50R	75R	90
		100Y	60R	100R	100R	90Y	50R	75R	100
		60R	100R	100R	100R	90Y	50R	75R	90
Electric Sherardized Cast Iron	1.82	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Gas Sherardized Malleable Iron	0.50	<10Ys	<10Ys	0d	10R	0	0	0d	0d
		<10Ys	<10Ys	0d	10R	0	0	0d	0d
		<10Ys	<10Ys	0d	0	0	0	0d	0d
Gas Sherardized Cast Iron	0.63	<10Ys	<10Ys	0d	0	0	0	0d	0d
		<10Ys	<10Ys	0d	0	0	0	0d	0d
		<10Ys	<10Ys	0d	0	0	0	0d	0d
Parkerized Malleable Iron	....	0	<10R	10R	10R	0	<10R	<10R	10
		0	15R	15R	40R	0	0	0	0
Parkerized Cast Iron	....	0	0<10R bolt	0 15R bolt	0 15R bolt	0	<10R	<10R	10
		0	0<10R bolt	0 15R bolt	0 15R bolt	0	<10R	<10R	10
		0	0<10R bolt	0 15R bolt	0 15R bolt	0	<10R	<10R	10
Hot Dip Aluminum Malleable Iron	3.16	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum Cast Iron	2.51	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	10
Amaloy Malleable Iron	....	75R	100R	100R	100R	50R	60R	75R	90
		75R	100R	100R	100R	50R	60R	70R	90
		40R	100R	100R	100R	50R	60R	90R	90
Amaloy Cast Iron	....	80R	80R	80R	85R	50R	60R	60R	70
		30R	80R	80R	85R	50R	60R	60R	70
		50R	80R	80R	85R	50R	60R	60R	60

ETALLIC COATINGS, ETC. (*Continued*).

etal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
-threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
	Tower Clamps										
0	0	0	0	0	0	0	0	0	0	Bolt 0.31	Electro Galvanized Malleable Iron
0	0	0	0	0	0	0	0	0	0	Nut 0.54	
0	0	0	0	0	0	0	0	0	0	Clamp 1.15	
0	0	0	0	0	0	0	0	0	0	Bolt 0.28	Electro Galvanized Cast Iron
0	0	0	0	0	0	0	0	0	0	Nut 0.56	
0	0	0	0	0	0	0	0	0	0	Clamp 0.90	
100R stud	0 100R nut	0 100R nut	0 100R nut	0	0	0	0	0	0	Bolt 0.02	Electro Galvanized Malleable Iron
100R stud	0 100R nut	0 100R nut	0 100R nut	0	0	0	0	0	0	Nut 0.01	
100R stud	0 100R nut	0 100R nut	0 100R nut	0	0	0	0	0	0	Clamp 0.46	
100R stud	0 100R nut	0 100R nut	0 100R nut	0	0	0	0	<10R	<10R	Bolt 0.04	Electro Galvanized Cast Iron
100R stud	0 100R nut	0 100R nut	0 100R nut	0	0	0	0	0	<10R	Nut 0.04	
100R stud	0 100R nut	0 100R nut	0 100R nut	0	0	0	0	<10R	<10R	Clamp 0.74	
0	0	0	0	0	0	0	0	0	0	1.53	Hot Dip Galvanized Malleable Iron
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.75	Hot Dip Galvanized Cast Iron
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0Rth	0Rth	2.00	Hot Dip Galvanized Malleable Iron
0	0	0	0	0	0	0	0	0Rth	0Rth		
0	0	0	0	0	0	0	0	0Rth	0Rth		
<10R nut	0	0	0	0	0	0	0	0Rth	0Rth	2.38	Hot Dip Galvanized Cast Iron
<10R nut	0	0	0	0	0	0	0	0Rth	0Rth		
<10R nut	0	0	0	0	0	0	0	0Rth	0Rth		
0	0	0	0	0	<10R	<10R	15R	0	<10Rth	0.28	Cadmium Plated Malleable Iron
0	0	0	0	0	<10R	<10R	60R	0	0		
0	0	<10Y	10R	0	<10R	<10R	10R	0	0		
0	0	0	0	0	<10R	20R	90R	0	0	0.28	Cadmium Plated Cast Iron
0	0	0	0	0	<10R	20R	90R	0	0		
0	0	0	0	0	<10R	<10R	50R	0	0		
<10R stud	0	<10R	40R	0	60R	100R	100R	20R	60R	0.15	Cadmium Plated Malleable Iron
<10R stud	15R	20R	50R	10R	100R	100R	100R	25R	100R		
<10R stud	<10R	50R	50R	<10R	50R	100R	100R	25R	90R	0.17	Cadmium Plated Cast Iron
<10R stud	<10R	30R	40R	<10R	40R	100R	100R	20R	90R		
<10R stud	<10R	30R	30R	<10R	80R	100R	100R	15R	80R		
<10R	10R	10R	10R	<10R	50R	100R	100R	100R	100R	1.75	Electric Sherardized Malleable Iron
<10R	15R	30R	40R	10R	90R	100R	100R	100R	100R		
<10R	50Y	100Y	90R	50Y	90R	100R	100R	100R	100R		
0	0	0	0	<10Y	10Y	10Y	<10R	<10R	<10R	1.82	Electric Sherardized Cast Iron
0	0	0	0	<10Y	10Y	10Y	<10R	0	0		
0	0	0	0	<10Y	10Y	25Y	<10R	<10R	<10R		
<10Y	<10Y	20Y	10R - 60Y	10Y	20Y	25Y	100Y	0	<10R	0.50	Gas Sherardized Malleable Iron
<10Y	<10Y	20Y	10R - 60Y	10Y	20Y	25Y	100Y	0	0		
<10Y	<10Y	10Y	10R - 60Y	10Y	20Y	50Y	100Y	0	0		
<10R	<10R	40R	60R	10Y	20Y	50Y	100Y	50R	100R	0.63	Gas Sherardized Cast Iron
<10R	<10R	40R	40R	10Y	20Y	50Y	100Y	50R	100R		
<10R	25R	40R	60R	10Y	20Y	50Y	100Y	50R	100R		
0	100R	100R	100R	0	100R	100R	100R	100R	100R	....	Parkerized Malleable Iron
0	100R	100R	100R	0	100R	100R	100R	100R	100R		
0	10R	20R	30R	0	<10R	10R	15R	100R	100R	....	Parkerized Cast Iron
0	10R	20R	20R	0	<10R	10R	25R	100R	100R		
0	10R	20R	20R	0	<10R	10R	25R	100R	100R		
0	0	0	0	0	0	0	0	0 50R nut	0Rth	3.16	Hot Dip Aluminum Malleable Iron
0	0	0	0	0	0	0	0	0 50R nut	0Rth		
0	0	0	0	0	0	0	0	0 50R nut	0Rth		
0	0	0	0	0	0	0	0	0 50R nut	0Rth	2.51	Hot Dip Aluminum Cast Iron
0	0	0	0	0	0	0	0	0 50R nut	0Rth		
0	0	0	0	0	0	0	0	0 50R nut	0Rth		
100R	100R	100R	100R	100R	100R	100R	100R	100R	100R	....	Amaloy Malleable Iron
100R	100R	100R	100R	100R	100R	100R	100R	95R	100R		
100R	100R	100R	100R	100R	100R	100R	100R	80R	100R		
60R	60R	60R	70R	60R	60R	60R	60R	80R	80R	....	Amaloy Cast Iron
60R	60R	60R	70R	60R	60R	60R	60R	80R	80R		
60R	60R	60R	70R	60R	60R	60R	60R	100R	100R		

TABLE V.—REPORT ON INSPECTION

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of
a - in angle; < - less than; e - ed

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	9 We
				1½ BY 1½ BY ⅛-IN. PLAIN STEEL ANGLES					
Electro Galvanized	0.47	0 0 0	0 0 0	10Ya 10Ra 20Ra	25Ra 25Ra 35Ra	0 0 0	0 20Ra 20Ya	0 40Ra 40Ra	<10 80 70
Electro Galvanized	1.09	0 0 0	0 0 0	0 0 0	0d 0d 0d	0d 0d 0d	40Y 0 0	<10Ra 0 0	<10 0 0
Hot Dip Galvanized	3.16	0 0 0	0 0 0	0 0 0	0d 0d 0d	0d 0d 0d	0 0 0	0 0 0	0 0 0
Hot Dip Aluminum	0.89	30Ra 0 0	90Ra 0 <10Ra	100R 60R 70R	100R 90R 90R	0d 0d 0d	0 0 0	0d 0d 0d	0 0 0
Cadmium Plated	0.12	0 0 0	0 0 0	100Y 100Y 100Y	10R 10R <10R	20Ra <10Ra <10Ra	80R 90R 75R	100R 100R 100R	100 100 100
Electric Sherardized	0.14	100Y 100Y 100Y	75R - 25Y 50R - 50Y 75R - 25Y	100R 100R 100R	100R 100R 100R	0 0 0	0d 0d 0d	0d 0d 0d	0 0 25
Gas Sherardized	....	0 0 0	0 0 0	0d 0d 0d	0d 0d 0d	<10R <10R <10R	90R 80R 95R	100R 100R 100R	100 100 100
Lead Plated	....	0 0 0	<10R* <10R* <10R*	<10R* <10R* <10R*	<10R* <10R* <10R*	0 0 0	0d 0d 0d	0d 0d 0d	<10 <10 <10
				1½ BY 1½ BY ⅛-IN. COPPER-BEARING STEEL ANGLES					
Electro Galvanized	0.76	0 0 0	0 <10Ra 0	15Ra 20Ra 15Y	30Ra 30Ra 35Ra	0d 0d 0d	20Ra <10Ra 20Ra	50Ra 50Ra 70Ra	70 70 80
Electro Galvanized	0.47	0 0 0	0 0 0	0 0 0	0d 0d 0d	0d 0d 0d	0 0 0	0 30Y <10Y	0 25 15
Hot Dip Galvanized	3.20	0 0 0	0 0 0	0 0 0	0d 0d 0d	0 0 0	0 0 0	0 0 0	0 0 0
Hot Dip Aluminum	1.11	20Ra 0 <10Ra	50R 10R 50R	75R 75R 75R	95R 90R 100R	0 0 0	0 0 0	0d 0d 0d	0 0 0
Cadmium Plated	0.65	0d 0d 0d	0d 0d 0d	0d 0d 0d	0d 0d 0d	<10R <10R 30R	70R 70R 90R	90R 80R 100R	100 100 100
Electric Sherardized	....	... ...	... ...	... ...	... ...	0d 0d 0d	0d 0d 0d	0d 0d 0d	0 0 0
Gas Sherardized	....	0 0 0	0 0 0	0d 0d 0d	0d 0d 0d	... ...	... ...	... ...	... ...
Lead Plated	....	0 0 0	<10R <10R <10R	<10R <10R <10R	<10R <10R <10R	0 0 0	0 0 0	0d 0d 0d	0 0 0

METALLIC COATINGS, ETC. (*Continued*).

tal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
-threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 eeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
1½ BY 1½ BY ⅛-in. PLAIN STEEL ANGLES											
0	0	0	0	0	0	10Ra	15Ra	0	0	0.47	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.09	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	<10R	0	<10Ra	0	0		
0	0	0	0	0	0	0	0	0	0	3.16	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.89	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	<10R	15R	30Ra	35Ra	10R	15R	0.12	Cadmium Plated
5R	20R	20R	25R	0	10R	<10Ra	<10Ra	0	0		
0R	<10R	<10R	<10R	<10R	<10R	30Ra	35Ra	0	0		
0Y	<10R	10R	90R	0	30Y	90Y	100Y	100Y	100Y	0.14	Electric Sherardized
0	0	0	0d	<10R	10R - 90Y	<10R - 90Y	10R - 90Y	50Y	50Y		
0	20Y	20Y	<10R	<10R	90Y	90Y	10R - 90Y	50Y	50Y		
0Y	100Y	100Y	30R	100Y	20R	95R	100R	50R - 50Y	75R - 25Y	....	Gas Sherardized
0Y	30R	60R	85R	100Y	20R	95R	100R	50R - 50Y	50R - 50Y		
0Y	100Y	100Y	20R	100Y	20R*	95R	100R	50R - 50Y	80R - 20Y		
0Re	<10R	10R	15R	<10R	10R*	20R*	20R*	10R	15R	....	Lead Plated
0Re	<10R	10R	15R	<10R	10R*	20R*	20R*	10R	10R		
0Re	15R	15R	20R	<10R	<10R*	<10R*	20R*	10R	10R		
1½ BY 1½ BY ⅛-IN. COPPER-BEARING STEEL ANGLES											
0	0	0	0	0	0	<10Y	<10Ra	0	0	0.76	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.47	Electro Galvanized
0	0	0	0	<10R	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	3.20	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.11	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	<10R	10R	40R	60R	0	0	0.65	Cadmium Plated
0	0	0	0	0	25R	60R	60R	<10Ra	<10R		
0	0	0	0	0	0	<10R	<10R	0	0		
0	0d	0d	0d	0	10Y	75Y	100Y	25Y	50Y	....	Electric Sherardized
0	0d	0d	0d	0	0	75Y	100Y	40Y	50Y		
0	0d	0d	0d	0	10Y	50Y	100Y	40Y	50Y		
..	...	...	...	...	...	...	...	...	...	....	Gas Sherardized
..	...	...	...	...	...	...	...	...	...		
..	...	...	...	...	...	...	...	...	...		
R*	15R*	30R	35R	<10R	<10R	<10R	<10R	10Re	10Re	....	Lead Plated
R*	<10R*	10R	15R	<10R	<10R	10R	25R	10Re	10Re		
R*	<10R*	15R	15R	<10R	<10R	10R	20R	10Re	10Re		

TABLE V.—REPORT ON INSPECTION OF

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of bas
a - in angle; < - less than; e - edges;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
No. 14 by 2½-in Plain Steel Flats									
Electro Galvanized	0 45	0	0	0	35R	0	0	0	80R
		0	0	90R	100R	0	0	0	50R
		0	10Y	95R	100R	0	0	0	10R
	0.70	0	0	0d	0d	0	0d	0d	0d
		0	0	0d	0d	0	0d	0d	0d
		0	0	0d	0d	0	0d	0d	0d
Hot Dip Galvanized	3 16	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
Hot Dip Aluminum	0 89	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	....	0	10Re	100R	100R	10R	100R	100R	100R
		0	60R	100R	100R	95R	100R	100R	100R
		<10Re	20R	100R	100R	20R	100R	100R	100R
Electric Sherardized	0 58	0	<10R	10R	10R - 90Y	10Y	0d	0d	0d
		0	0	0d	100Y	10Y	<10R	<10R	<10R
		0	<10R	<10R	10R - 90Y	10Y	<10R	<10R	15R
Gas Sherardized	....	100Ys	100Ys	100Ys	100Ys	100Y	100Ys	0d	0d
		100Ys	100Ys	100Ys	100Ys	100Y	100Ys	0d	0d
		100Ys	100Ys	100Ys	100Ys	100Y	100Ys	0d	0d
Lead Plated	....	0	<10R*	<10R	<10R	0	0	0d	0d
		0	<10R*	<10R	<10R	0	0	0d	0d
		0	<10R*	<10R	<10R	0	0	0d	0d
No. 14 by 2½-in. Copper-Bearing Steel Flats									
Electro Galvanized	0.29	0	0	10R - 60Y	90R	0	50R	80R	100R
		0	0	0	0	0	0	50Y	90R
		0	0	0	0	0	0	50Y	85R
	0.62	0	0	0d	0d	0	0	0	0
		0	0	0d	0d	0	0	0	0
		0	0	0d	0d	0	0	0	0
Hot Dip Galvanized	3 20	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
Hot Dip Aluminum	0.47	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	....	0	<10R	100R	100R	0	95R	100R	100R
		<10R	30R	100R	100R	0	20R	100R	100R
		<10R	95R	100R	100R	0	20R	100R	100R
Electric Sherardized	....	<10R	<10R	<10R	10R	100Ys	<10R	<10R	<10R
		15Y	15R	20R	30R	100Ys	<10R	<10R	10R
		10Y	15R	20R	30R	100Ys	<10R	<10R	<10R
Gas Sherardized	....	100Ys	50Ys	0d	0d	100Ys	100Ys	0d	0d
		100Ys	100Ys	0d	0d	100Ys	100Ys	0d	0d
		100Ys	75Ys	0d	0d	100Ys	100Ys	0d	0d
Lead Plated	....	0	<10R	<10R	<10R	0	0	0d	0d
		0	<10R	<10R	<10R	0	0	0d	0d
		0	<10R	<10R	<10R	0	0	0d	0d

ETALLIC COATINGS, ETC. (*Continued*).

etal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
- threads; n - near; s - stain.

	Exposure at State College, Pa.			Exposure at Sandy Hook, N J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
	No. 14 BY 2½-IN. PLAIN STEEL FLATS										
0	0	0	0	0	0	0	0	0	0	0.45	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.70	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	3.16	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.89	Hot Dip Aluminum
0	0	0	0	10R	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	<10R	60R	90R	100R	0	0	....	Cadmium Plated
0	0	0	0	0	0	<10Y	10R	0	0		
0	0	0	0	0	<10Y	15R	30R	0	0		
10Y	100Y	100Y	100Y	<10R	<10R - 90Y	<10R - 90Y	10R - 90Y	10R	10R - 90Y	0.58	Electric Sherardized
10Y	100Y	100Y	100Y	<10Y	<10R - 90Y	<10R - 90Y	10R - 90Y	10R	10R - 90Y		
10Y	100Y	10R - 90Y	90Y - 10R	10Y	<10R - 90Y	<10R - 90Y	<10R - 90Y	<10R	<10R - 90Y		
00Y	100Y	100Y	100R	10Y	50Y	100Y	100Y	50Y	10R - 90Y	....	Gas Sherardized
50Y	100Y	100Y	100R	75Y	100Y	100Y	100Y	10Y	<10R - 40Y		
00Y	100Y	100Y	100R	50Y	80Y	100Y	100Y	10Y	<10R - 90Y		
10Re	10R	10R	10R	<10Re	<10R	<10R	<10R	<10Re	<10Re	....	Lead Plated
0	<10R	10R	10R	<10Re	<10R	<10R	<10R	<10Re	<10Re		
0	<10R	10R	10R	<10Re	<10R	<10R	<10R	<10Re	<10Re		
	No. 14 BY 2½-IN. COPPER-BEARING STEEL FLATS										
0	0	0	0	0	0	0	0	0	0	0.29	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.62	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	3.20	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.47	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	15Re	20R	....	Cadmium Plated
0	0	0	0	0	0	0	0	<10Re	20R		
0	0	0	0	10R	50R	90R	100R	<10Re	<10R		
10R	<10R	10R - 90Y	10R - 90Y	<10Y	100Y	100Y	100Y	<10Re - 25Y	<10R - 90Y	....	Electric Sherardized
10R	<10R	10R - 90Y	100Y	<10Y	100Y	100Y	100Y	<10Re - 25Y	<10R - 90Y		
10R	10R	10R - 90Y	10R - 90Y	10R	<10R	10R - 90Y	15R - 85 Y	<10Re - 25Y	<10R - 90Y		
50Y	100Y	100Y	100Y	10Y	70Y	75Y	100Y	<10Re - 25Y	<10R - 75Y	....	Gas Sherardized
50Y	100Y	100Y	100Y	50Y	100Y	100Y	100Y	25Y	<10R - 90Y		
25Y	100Y	100Y	100Y	75Y	100Y	100Y	100Y	15R	<10R - 75Y		
10Re	<10Re	<10Re	<10R*	<10Re	<10R*	<10R*	<10R*	<10Re	10R	....	Lead Plated
10Re	<10Re	<10Re	<10R*	<10Re	<10R*	<10R*	<10R*	<10Re	<10R		
10Re	<10Re	<10Re	<10R*	<10Re	<10R*	<10R*	<10R*	<10Re	<10R		

TABLE V.—REPORT ON INSPECTION

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of
a - in angle; < - less than; e -

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
						$\frac{1}{4}$ by 6-in. Bolts			
Sherardized	0.68	90Ys	10Ys	0d	0d	100Ys	0	0d	0d
		90Ys	10Ys	0d	0d	100Ys	0	0d	0d
		90Ys	10Ys	0d	0d	100Ys	0	0d	0d
	1.10	0	0	0	0	0d	0	0d	0d
		0	0	0	0	0d	0	0d	0d
		0	0	0	0	0d	0	0d	0d
Hot Dip Galvanized	1.61	0	0	0	0	0	0	40Y	50Y
		0	0	0	0	0	0	40Y	50Y
		0	0	0	0	0	0	40Y	50Y
Electro Galvanized	0.33	0	<10R	80R	100R	0	10R	90R	100R
		0	50R	95R	100R	50R	90R	100R	100R
		10R	95R	100R	100R	40R	90R	100R	100R
Cadmium Plated	Bolt 0.29 Nut 0.10	100R	100R	100R	100R	0	80R	100R	100R
		100R	100R	100R	100R	0	...	...	...
		100R	100R	100R	100R	0	80R	100R	100R
	Bolt 0.22 Nut 0.11	0	10Y	90R	100R	95R	100R	100R	100R
		0	10Y	90R	100R	100R	100R	100R	100R
		0	0	90R	100R	100R	100R	100R	100R
						$\frac{5}{8}$ by $2\frac{1}{2}$-in. Bolts			
Sherardized	0.87	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
	0.70	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Hot Dip Galvanized	1.40	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Cadmium Plated	....	0	40R	95R	100R	0	90R	100R	100R
		0	30R	95R	100R	0	90R	100R	100R
		0	30R	95R	100R	0	90R	100R	100R
	1.49	50R	100R	100R	100R	90R	100R	100R	100R
		100R	100R	100R	100R	90R	100R	100R	100R
		95R	100R	100R	100R	100R	100R	100R	100R
Electro Galvanized	0.20	0	30R	100R	100R	<10R	20R	100R	100R
		0	0	50R	100R	<10R	20R	100R	100R
		0	25R	60R	100R	<10R	90R	100R	100R
						$\frac{1}{2}$ by $2\frac{1}{2}$-in. Bolts			
Sherardized	0.84	0	0	0	0	0d	0	0	0d
		0	0	0	0	0d	0	0	0d
		0	0	0	0	0d	0	0	0d
	0.79	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized	1.48	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Electro Galvanized	0.21	0	0	90R	100R	<10R	40R	100R	100R
		0	0	95R	100R	0	<10R	100R	100R
		0	0	95R	100R	<10R	90R	100R	100R
	0.20	0	50R	100R	100R	0	100R	100R	100R
		0	70R	100R	100R	10R	100R	100R	100R
		0	70R	100R	100R	<10R	100R	100R	100R
Cadmium Plated	0.30	100R	100R	100R	100R	100R	100R	100R	100R
		100R	100R	100R	100R	100R	100R	100R	100R
		100R	100R	100R	100R	100R	100R	100R	100R

ETALLIC COATINGS, ETC. (*Continued*).

tal; Y – yellow or orange alloy rust; * – rust spots widely distributed; d – black or dark surface film (soot or dirt);
-threads; n – near; s – stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
$\frac{1}{4}$ BY 6-IN. BOLTS											
10Ys	100Y	100Y	100Y	20Y	100Y	100Y	20R – 80Y	50R – 50Y	100nR	0.68	Sherardized
0	100Y	100Y	100Y	20Y	100Y	100Y	20R – 80Y	50R – 50Y	100nR		
0	100Y	100Y	100Y	20Y	100Y	100Y	20R – 80Y	50R – 50Y	100nR		
0	0	0	0	0	0	0	0	0	0	1.10	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.61	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	<10R	70R	85R	<10R nut	<10R	0.33	Electro Galvanized
0	0	0	0	0	0	<10R	<10R	0	0		
0	0	0	0	0	...	...	...	0	<10R		
0	15R	70R	95R	0	0	0	0	15R	20R	Bolt 0.29 Nut 0.10	Cadmium Plated
0	0	0	0	0	0	0	0	60R	90R		
<10R	20R	80R	95R	0	...	...	...	0	50R		
0	0	0	0	60R	100R	100R	100R	0	0	Bolt 0.22 Nut 0.11	
0	0	0	0	10R	80R	100R	100R	0	0		
0	0	0	0	50R	100R	100R	100R	0	0		
$\frac{5}{8}$ BY $2\frac{1}{2}$-IN. BOLTS											
0	0	0d	0d	0	0	10Y	10Y	0	0	0.87	Sherardized
0	0	0d	0d	0	0	10Y	10Y	0	0		
0	0	0d	0d	0	0	10Y	10Y	0	0		
<10R	20R – 80Y	100nR	100nR	25Y	100Y	100Y	100nR	50R – 50Y	100nR	0.70	
<10R	20R – 80Y	100nR	100nR	25Y	100Y	100Y	100nR	50R – 50Y	100nR		
<10R	20R – 80Y	100nR	100nR	25Y	100Y	100Y	100nR	50R – 50Y	100nR		
0	0	0	0	0	0	0	0	0	0	1.40	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	<10Y	<10R	0	0	....	Cadmium Plated
0	0	0	0	<10R	<10R	<10R	15R	0	0		
0	0	0	0	0	0	<10Y	<10R	0	0		
40R	100R	100R	90R	75R	100R	100R	100R	90R	95R	1.49	
<10R	<10R	30R	70R	75R	100R	100R	100R	10R	40R		
40R	90R	100R	100R	20R	100R	100R	100R	75R	95R		
0	0	<10R	<10R	0	0	<10R	70R	<10Rth	10Rth	0.20	Electro Galvanized
0	0	0	0	0	0	0	<10R	<10Rth	65Rth		
0	0	0	0	0	0	0	10R	0	10Rth		
$\frac{1}{2}$ BY $2\frac{1}{2}$-IN. BOLTS											
0	0	0	0	0	0	10Y	100Y	0	0	0.84	Sherardized
0	0	0	0	0	0	10Y	100Y	0	0		
0	0	0	0	0	0	10Y	100Y	0	0		
<10Y	100Y	100nR	100nR	60Y	100Y	100Y	100nR	50nR – 50Y	100nR	0.79	
<10Y	100Y	100nR	100nR	60Y	100Y	100Y	100nR	50nR – 50Y	100nR		
<10Y	100Y	100nR	100nR	60Y	100Y	100Y	100nR	50nR – 50Y	100nR		
0	0	0	0	0	0	0	0	0	0	1.48	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	10R	0	<10R	0.21	Electro Galvanized
0	0	0	0	0	0	0	50R	10Rth	10R		
0	0	0	0	0	0	0	15R	10Rth	15R		
0	0	0	0	0	0	0	30R	0	0	0.20	
0	0	0	0	0	<10Y	<10R	20R	0	0		
0	0	0	0	0	<10Y	<10R	50R	0	0		
<10R	<10R	50R	50R	20R	90R	100R	100R	50R	95R	0.30	Cadmium Plated
<10R	<10R	50R	60R	30R	90R	100R	100R	40R	60R		
<10R	<10R	50R	70R	40R	95R	100R	100R	50R	80R		

TABLE V.—REPORT ON INSPECTION

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of
a - in angle; < - less than; e -

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.		
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks
						3/8 BY 1 1/2-IN. BOLTS		
Sherardized	1.20	0 0 0	0 0 0	0d 0d 0d	0d 0d 0d	0 0 0	0 0 0	0d 0d 0d
	0.89	0 0 0	0 0 0	0d 0 0	0d 0 0	0d 0d 0d	0 0 0	0d 0d 0d
Hot Dip Galvanized	1.45	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0
Electro Galvanized	0.18	0 0 0	40Y 0 10R	100R 90R 100R	100R 100R 100R	0 0 0	90R 20R 25R	90R 90R 90R
Cadmium Plated	0.14	<10R 0 0	80R 80R 90R	100R 100R 100R	100R 100R 100R	<10R <10R <10R	100R 100R 100R	100R 100R 100R
	0.15	90R 100R 100R	100R 100R 100R	100R 100R 100R	100R 100R 100R	100R 100R 100R	100R 100R 100R	100R 100R 100R
						1-IN ROOFING NAILS		
Sherardized	0 90 0.86	Ys Ys	Ys Ys	Ys Ys	Ys Ys	0 0	0 0	0 0
Cadmium Plated	....	<10R[a]	90R	100R	100R	40R[a]	100R	100R
Hot Dip Galvanized	1.34 1.15	0 0	0 0	0 0	0 0	0 0	0 0	30Y 0
Electro Galvanized	.. .	40R	90R	100R	100R	30R - 30Ys	40R	50R
Amaloy	....	30R	35R	40R	50R	0d	0d	0d
						NO. 14 BY 2 1/2-IN. WOOD SCREWS		
Sherardized	0.94 0.86	50Y 50Y	80Y 100Y	<10R <10R	<10R <10R	100Ys 100Ys	100Ys 0	100Y 0
Cadmium Plated	0.07	0	<10R	15R	90R	0 on 98% 50R on 2%	20R	100R
Hot Dip Galvanized	1.26	0	0	0	0	0	0	10Y
Cadmium Plated	0.04	98R	100R	100R	100R	100R	100R	100R
Hot Dip Galvanized	....	0	0	0	0	0	0	10Y
Parkerized	....	1R	100R	100R	100R	<10R[a]	25R	100R
Electro Galvanized	....	0d	10R	40R	90R	<10Rth	50R	75R

[a] On two specimens

ETALLIC COATINGS, ETC. (*Continued*).

tal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
-threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
	$\frac{3}{8}$ BY $1\frac{1}{2}$-IN. BOLTS										
10Y	100Y	100nR	100nR	0	0	0	0	50R - 50Y	100nR	1.20	Sherardized
10Y	100Y	100nR	100nR	0	0	0	0	50R - 50Y	100nR		
10Y	100Y	100nR	100nR	0	0	0	0	50R - 50Y	100nR		
0	0	0	0	50Y	100Y	100Y	100nR	0	0	0.89	
0	0	0	0	50Y	100Y	100Y	100nR	0	0		
0	0	0	0	50Y	100Y	100Y	100nR	0	0		
0	0	0	0	0	0	0	0	0	0	1.45	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	10R	0	10R	0.18	Electro Galvanized
0	0	0	0	0	<10R	70R	80R	0	<10R		
0	0	0	0	0	0	0	30R	0	10R		
10R	50R	50R	60R	0	0	10Y	40R	0	0	0.14	Cadmium Plated
0	0	0	0	0	0	...	...	0	0		
0	0	0	0	0	0	...	...	0	0		
0	0	20R	50R	10R	90R	100R	100R	20Yth	50R	0.15	
0	0	10R	60R	<10R	80R	100R	100R	10Yth	30R		
0	0	10R	60R	<10R	80R	100R	100R	10Yth	20R		
	1-IN. ROOFING NAILS										
10Y	100Y	100Y	100nR	90Y	100Y	100Y	100Y	5Y	100Y	0.90	Sherardized
10Y	30Y	50Y	50nR	0 on 60% <10R on 40%	<10R	100nR	100nR	0	10Y	0.86	
0	0	0	0	0	0	20R	50R	0	0	....	Cadmium Plated
0	0	0	0	0	0	0	0	0	0	1.34	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0	1.15	
0	0R[a]	20R	40R	0 on 94% <10R on 6%	40R	50R	50R	50R	60R	....	Electro Galvanized
40R*	100R	100R	100R	30R	70R	75R	90R	50R	50R	....	Amaloy
	NO. 14 BY $2\frac{1}{2}$-IN. WOOD SCREWS										
10Y	90Y	100Y	100nR	20nR	100nR	100nR	100nR	50Y	<10R - 50Y	0.94	Sherardized
20Y	20Y	20Y	20Y	<10Y*	<10Y	100Y	100Y	<10Y	<10R	0.86	
0	0	0 on 98% R on 2%	0 on 98% R on 2%	0 on 99% R on 1%	0 on 98% R on 2%	0 on 98% R on 2%	0 on 98% R on 2%	0	0	0.07	Cadmium Plated
0	0	0	0	0	0	0	0	0	0	1.26	Hot Dip Galvanized
0R	100R	100R	100R	95R	90R	90R	100R	90R	95R	0.04	Cadmium Plated
0	0	0	0	0	0	0	0	0	0	....	Hot Dip Galvanized
0R	90R	100R	100R	<10R	100R	100R	100R	100R	100R	....	Parkerized
0	0	0	0	...	...	...	...	0 on 95% 10R on 5%	0 on 80% 10R on 20%	....	Electro Galvanized

TABLE V.—REPORT ON INSPECTION

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of
a - in angle; < - less than; e - edge

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Week
KNOCK OUT BOXES									
Electro Galvanized	0.21	0	0	0	<10R	0	<10R	<10R	25R
		0	0	0	<10R	0	0	<10Y	10R
		0	0	0	0	0	0	<10Y	<10R
	0.16	0	<10Y	10Y	<10R	0	<10R	10R	30R
		0	<10Y	10Y	15R	0	<10R	<10R	<10R
		0	<10Y	10Y	20R	0	0	10Y	20R
Hot Dip Galvanized	1.56	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
Cadmium Plated	0.12	60R	100R	100R	100R	80R	100R	100R	100
		50R	100R	100R	100R	100R	100R	100R	100
		30R	100R	100R	100R	100R	100R	100R	100
	0.19	<10R	40R	80R	100R	10R	50R	100R	100
		<10R	60R	80R	100R	10R	50R	100R	100
		<10R	40R	80R	100R	10R	50R	100R	100
Electric Sherardized	0.28	100Ys	25Ys	0d	60R	100Ys	0d	0	25
		100Ys	<10Ys	0d	60R	100Ys	0d	10Y	100
		100Ys	<10Ys	0d	40R	100Ys	0d	0	20
Gas Sherardized	0.19	100Ys	15Ys	0d	10R	100Ys	0d	0d	0
		100Y	95R	95R	100Y	100Ys	0d	0	80
		100Ys	25Ys	0d	80R	100R	100R	100R	100
Electric Sherardized	0.28	0	0	0	0d	0	0	0d	0
		0	0	0	0d	0	0	0d	0
		0	0	0	0d	0	0	0d	0
Parkerized	....	<10R	25R	40R*	60R	0	<10R	<10R	10
		<10R	25R	40R*	60R	0	0	0	0
		0	25R	40R*	60R	0	20R	25R	40
Amaloy	....	<10R	10R	15R	15R	0	0	0	0
		<10R	10R	15R	15R	0	0	0	0
		<10R	10R	15R	15R	0	0	0	0
Hot Dip Aluminum	1.84	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
STEEL HINGES									
Cadmium Plated	0.29	10R	60R	90R	100R	<10R	70R	95R	100
		0	50R	90R	100R	30R	90R	95R	100
		<10R	60R	90R	100R	10R	80R	95R	100
	0.32	0	20R	90R	100R	0	20R	90R	100
		0	<10R	90R	100R	0	20R	90R	100
		0	20R	90R	100R	0	20R	90R	100
Hot Dip Galvanized	1.54	0	0	<10Y	<10R	0	0	10Y	<1
		0	0	0	<10R	0	0	<10Y	<1
		0	0	0	<10R	0	0	0	0
Electric Sherardized	0.40	20R	100R	100R	100R	90R	100R	100R	100
		50R	100R	100R	100R	80R	100R	100R	100
		15R	100R	100R	100R	90R	100R	100R	100
Gas Sherardized	0.68	100Ys	60Ys	0	0	100Ys	0d	0d	0
		100Ys	60Ys	0	0	100Ys	0d	0d	0
		100Ys	60Ys	0	0	100Ys	0d	0d	0
Parkerized	....	0	0	0	<10R	0	0d	0d	0
		0	0	0	<10R	0	0d	0d	0
		0	0	0	0	0	0d	0d	0
Electro Galvanized	0.19	<10R	75R	90R	100R	40R	90R	95R	100
		15R	90R	100R	100R	10R	90R	95R	100
		80R	95R	100R	100R	20R	90R	95R	100

ETALLIC COATINGS, ETC. (*Continued*).

al; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
-threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
KNOCK OUT BOXES											
0	0	0	0	0	0	0	0	0	0	0.21	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	<10Y	<10R	<10R	<10R	0.16	
0	0	0	0	0	0	<10Y	<10R	<10R	<10R		
0	0	0	0	0	0	<10Y	<10R	<10R	<10R		
0	0	0	0	0	0	0	0	0	0	1.56	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	<10R	10R	25R	80R	100R	100R	100R	75R	95R	0.12	Cadmium Plated
0	0	0	<10R	<10R	10R	80R	90R	10Re	30R		
0	<10R	10R	40R	<10R	10R	80R	90R	0	<10R		
<10R	15R	20R	40R	<10R	50R	80R	90R	0	0	0.19	
0	0	0	<10R	0	<10Y	<10R	10R	0	0		
0	0	0	<10R	0	<10R	<10R	20R	0	0		
60Y	100Y	100nR	100nR	90Y	100Y	100Y	10R - 90Y	100Y	100nR	0.28	Electric Sherardized
60Y	100Y	100nR	100nR	90Y	100Y	100Y	50R - 50Y	100Y	100nR		
60Y	100Y	100nR	100nR	30Y	100Y	100Y	100Y	100Y	100nR		
25R	100R	100R	100R	100Y	100Y	100Y	100Y	100Y	100nR	0.19	Gas Sherardized
25R	100R	100R	90R	100Y	100Y	100Y	100Y	100R	100R		
25R	100R	100R	100R	40Y	100Y	100Y	100Y	100R	100R		
0	0	0	0	0	0	0	0	0	0	0.28	Electric Sherardized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	100R	100R	100R	<10R	50R	50R*	60R*	100R	100R	....	Parkerized
0	100R	100R	100R	0	0	10R*	10R*	100R	100R		
0	15R	20R	30R	<10R	50R	50R*	50R*	100R	100R		
40R	40R	50R*	60R*	20R	50R	50R*	60R*	50Re	20R	....	Amaloy
40R	50R	50R*	60R*	20R	50R	50R*	60R*	50Re	20R		
40R	50R	50R*	60R*	20R	50R	50R*	60R*	50Re	20R		
0	0	0	0	0	0	0	0	0	0	1.84	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
STEEL HINGES											
0	0	0	0	0	0	<10R	15R	0	<10R	0.29	Cadmium Plated
0	0	0	0	0	0	<10R	20R	0	0		
0	0	0	0	0	20R	20R	50R	0	<10R		
0	0	0	0	0	0	<10R	<10R	0	0	0.32	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.54	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
80Y	20R - 80Y	90R	100R	100Y	100R	100R	100R	20Y	50Y	0.40	Electric Sherardized
80Y	100Y	90R	100R	100Y	100R	100R	100R	20Y	50Y		
10R	20R - 80Y	90R	100R	10R - 90Y	100R	100R	100R	20Y	50Y		
0	0	60Y	100Y	20Y	50Y	50Y	100Y	0	0	0.68	Gas Sherardized
20Y	80Y	80Y	100Y	10Y	40Y	50Y	100Y	0	0		
0	<10Y	60Y	100Y	10Y	40Y	50Y	100Y	0	0		
0	<10R	20R	40R	0	<10R	10R	50R	75R	100R	....	Parkerized
0	<10R	20R	50R	0	<10R	30R	80R	75R	100R		
0	<10R	20R	30R	0	<10R	20R	60R	60R	70R		
0	0	0	0	0	<10R	50R	70R	20R	90R	0.19	Electro Galvanized
0	0	0	0	0	<10R	60R	80R	80R	100R		
0	0	0	0	0	0	0	30R	<10R	40R		

TABLE V.—REPORT ON INSPECTION

Abbreviations and Symbols Used: 0 – no rust; 5, 10, 25, 100 – approximate percentages; R – rusting of
a – in angle; < – less than; e –

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa. 16 Weeks	43 Weeks	68 Weeks	95 Weeks	Exposure at Altoona, Pa. 17 Weeks	44 Weeks	69 Weeks
					BULL DOG CLAMPS			
Electro Galvanized	3.41	0	0	0	<10R	0	0	0
		0	0	0	0	0	0	0
		0	0	0	<10R	0	0	0
Hot Dip Galvanized	1.88	0	0	0d	0d	0	0	0
		0	0	0d	0d	0	0	0
		0	0	0d	0d	0	0	0
Cadmium Plated	0.22	<10R	100R	100R	100R	10R	100R	100R
		0	100R	100R	100R	20R	100R	100R
		0	100R	100R	100R	20R	100R	100R
	0.17	10R	100R	100R	100R	50R	90R	90R
		40R	100R	100R	100R	50R	90R	90R
		80R	100R	100R	100R	50R	90R	90R
Gas Sherardized	0.46	50Ys	0	0	0	80Ys	50Ys	0d
		50Ys	0	0	30R	80Ys	50Ys	0d
		50Ys	0	0	10R	80Ys	50Ys	0d
Electric Sherardized	1.25	20Y	20Y	20Y	10R	0	0	0d
		0	0	0	0	0	0	0d
		20Ys	0	0	0	0	0	0d
	0.58	0	0	0	0	0	0	0d
		0	0	0	0	0	0	0d
		0	0	0	0	0	0	0d
Hot Dip Aluminum	1.35	0	0	0d	0d	0	0	0d
		0	0	0d	0d	0	0	0d
		0	0	0d	0d	0	0	0d
Parkerized	....	0	0	0d	0d	0	0	0d
		0	0	0d	0d	0	0	0d
		0	0	0d	0d	0	0	0d
					¼ BY 3-IN. PLAIN STEEL FLATS			
Electro Galvanized	0.76	0	0	0	0	0	0	0
		0	0	0	0	0	0	20R – 60Y
		0	0	0	0	0	0	0
	0.45	[a]0	0	0	0	0	0	0
		[a]0	0	0	0	0	0	0
		0	0	0	0	0	0	0
Hot Dip Galvanized	2.49	0	0	0	0	0	0	0
		0	0	0	0	0	0	0
		0	0	0	0	0	0	0
Hot Dip Aluminum	0.90	0	0	0d	0d	0	0	0
		0	0	0d	0d	0	0	0
		0	0	0d	0d	0	0	0
Cadmium Plated	0.23	0	<10R	90R	100R	0	30R	100R
		0	0	90R	100R	0	90R	100R
		0	40R	100R	100R	<10R	90R	100R
Electric Sherardized	....	0	0	0d	100Y	0	0d	0d
		0	0	0d	100Y	<10R	100R	100R
		0	0	0d	100Y	100Y	100R	100R
Gas Sherardized	0.12	20R – 80Y	100R	100R	100R	50R – 50Y	100R	100R
		100Y	100R	100R	100R	10R – 90Y	100R	100R
		100Y	100R	100R	100R	50R – 50Y	100R	100R
Lead Plated	....	0	<10R	<10R	10R	0	0	0
		0	<10R	<10R	10R	0	0	0
		0	<10R	<10R	15R	0	0	0

[a] Damaged.

METALLIC COATINGS, ETC. (*Continued*).

metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); th-threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
BULL DOG CLAMPS											
0	0	0	0	0	0	0	0	0	0	3.41	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.88	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	<10R	100R	100R	100R	<10R	50R	0 22	Cadmium Plated
0	0	0	0	<10R	100R	100R	100R	<10R	50R		
0	0	0	0	0	100R	100R	100R	<10R	25R		
100R	100R	100R	100R	0	100Ys	100Y	90R	100R	100R	0.17	
100R	100R	100R	100R	0	100Ys	100Y	80R	100R	100R		
100R	100R	100R	100R	0	100Ys	100Y	80R	100R	100R		
0	0	0	0	0	0d	100Y	100Y	20Y	50Y	0.46	Gas Sherardized
0	0	0	0	0	0d	100Y	100Y	80Y	100Y		
0	0	0	0	0	0d	100Y	100Y	50Y	50Y		
0	0	0	0	0	0d	100Y	100Y	0	0	1.25	Electric Sherardized
0	0	0	0	0	0d	100Y	100Y	0	0		
0	0	0	0	0	0d	100Y	100Y	0	<10Y		
0	0	0	0	0	0	0	0	0	<10Y	0.58	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.35	Hot Dip Aluminum
<10R	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	10R	30R	40R	<10Re	25R	50R	70R	100R	100R	....	Parkerized
0	10R	30R	40R	<10Re	25R	50R	70R	100R	100R		
0	10R	30R	40R	<10Re	25R	50R	70R	100R	100R		
¼ BY 3-IN. PLAIN STEEL FLATS											
0	0	0	0	0	0	0	0	0	0	0.76	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.45	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	20R[a]	20R		
0	0	0	0	0	0	0	0	0	0	2.49	Hot Dip Galvanized
0	0	0	0	0	<10R	<10R	<10R	0	0		
0	0	0	0	0	<10R	<10R	<10R	0	0		
0	0	0	0	0	0	0	0	0	0	0.90	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.23	Cadmium Plated
0	0	0	0	0	0	0	<10R	0	0		
0	0	0	0	0	0	0	<10R	0	0		
0	60Y	75Y	100Y	<10Y	100Y	100Y	10R - 90Y	20Y	50Y	....	Electric Sherardized
0	60Y	75Y	100Y	0	100Y	100Y	10R - 90Y	30Y	75Y		
0	60Y	75Y	100Y	<10Y	100Y	100Y	10R - 90Y	25Y	75Y		
100Y	20R - 80Y	40R - 60Y	100R	100Y	25R	100R	100R	30R - 70Y	60R - 40Y	0.12	Gas Sherardized
100Y	<10R - 90Y	10R - 90Y	75R - 25Y	100Y	90R	100R	100R	20R - 80Y	40R - 60Y		
100Y	100Y	100Y	25R - 75Y	100Y	10R - 90Y	100R	100R	30R - 70Y	60R - 40Y		
<10R	15R	30R*	50R*	<10Re	10R*	10R*	15R*	<10R	<10R	....	Lead Plated
<10R	10R	30R*	35R*	<10Re	10R*	10R*	15R*	10R	10R		
<10R	<10R	30R*	25R*	<10Re	10R*	10R*	10R*	10R	10R		

TABLE V.—REPORT ON INSPECTION OF

Abbreviations and Symbols Used: 0 - no rust; 5, 10, 25, 100 - approximate percentages; R - rusting of bas
a - in angle; < - less than; e - edge;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa. 16 Weeks	Exposure at Brunot Island, Pa. 43 Weeks	Exposure at Brunot Island, Pa. 68 Weeks	Exposure at Brunot Island, Pa. 95 Weeks	Exposure at Altoona, Pa. 17 Weeks	Exposure at Altoona, Pa. 44 Weeks	Exposure at Altoona, Pa. 69 Weeks	Exposure at Altoona, Pa. 96 Weeks
¼ BY 3-IN. COPPER-BEARING STEEL FLATS									
Electro Galvanized	0.84	0	0	0	15Y	0	0	0	0
		0	0	0	0	0	0	0	10R - 50Y
		0	0	0	0	0	0	0	0
	0.66	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Galvanized	2.67	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.66	0	0	0	0	0	0	0d	0d
		0	0	0	0	0	0	0d	0d
		0	0	0	0	0	0	0d	0d
Cadmium Plated	0.27	0	10Y	90R	100R	10R	30R	100R	100R
		0	10Y	80R	100R	10R	85R	100R	100R
		0	<10R	90R	100R	10R	90R	100R	100R
Electric Sherardized	....	0	0d	0d	100nR	0d	0d	0d	10R - 90Y
		0	0d	0d	100nR	0d	0d	0d	100Y
		0	0d	0d	100nR	0d	0d	0d	100Y
Gas Sherardized	0.18	100Y	100R	100R	100R	50R - 50Y	100R	100R	100R
		100Y	100R	100R	100R	40R - 60Y	100R	100R	100R
		100Y	100R	100R	100R	50R - 50Y	100R	100R	100R
Lead Plated	....	0	<10R*	<10R*	<10R*	0	0	0d	<10R
		0	<10R*	<10R*	10R*	0	0	0d	<10R
		0	<10R*	<10R*	10R*	0	0	0d	<10R
NO. 209 WINDOW FRAME SECTIONS									
Electro Galvanized	0.67	0	0	10Ya	30Ra	0	<10Ra	40Ra	75R
		0	0	10Ya	20Ra	0	20Ra	60Ra	90R
		0	<10Ra	50Ra	70Ra	0	<10Ya	20Ra	60R
	0.24	0	0	0d	0d	0	0	0	10nR
		0	0	0d	<10Ra	0	0	0	0
		0	0	0d	0d	0	0	10Y	20R
Hot Dip Galvanized	3.10	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum	0.61	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	0.24	30R	90R	100R	100R	25Ra	70R	90R	100R
		<10R	70R	100R	100R	20Ra	70R	90R	100R
		60R	90R	100R	100R	30Ra	70R	90R	100R
Electric Sherardized	0.52	10Ys	10Ys	0d	0d	0d	0d	0d	0d
		10Ys	10Ys	0d	0d	0d	0d	0d	0d
		10Ys	10Ys	0d	0d	0d	0d	0d	0d
Amaloy	....	<10R*	<10R*	<10R*	<10R*	0	0	0	0d
		<10R*	<10R*	<10R*	<10R*	0	0	0	0d
		<10R*	10R*	20R*	30R*	0	0	0	0d

METALLIC COATINGS, ETC. (*Continued*).

etal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt);
-threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz. per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
¼ BY 3-IN. COPPER-BEARING STEEL FLATS											
0	0	0	0	0	0	0	0	0	0	0.84	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	<10R	<10R	<10R	0	0	0.66	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	2.67	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.66	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	<10R	40R	0	0	0.27	Cadmium Plated
0	0	0	0	0	45R	70R	90R	0	0		
0	0	0	0	0	0	0	0	0	0		
0	80Y	100Y	10R - 90Y	<10Y	100Y	100Y	100Y	25Y	90Y	....	Electric Sherardized
0	80Y	100Y	100Y	<10Y	100Y	100Y	100Y	25Y	90Y		
0	80Y	100Y	100Y	<10Y	100Y	100Y	100Y	50Y	90Y		
100Y	100Y	10R - 90Y	50R - 50Y	100Y	10R - 90Y	25R - 75nR	100R	25R - 75Y	50R - 50Y	0.18	Gas Sherardized
100Y	100Y	10R - 90Y	50R - 50Y	100Y	10R - 90Y	25R - 75nR	100R	25R - 75Y	30R - 70Y		
100Y	100Y	10R - 90Y	75R - 25Y	100Y	100Y	25R - 75nR	100R	40R - 60Y	75R - 25Y		
<10R	15R	30R*	40R*	<10Re	10R*	10R*	30R*	20R	20R	....	Lead Plated
<10R	10R	20R*	25R*	<10Re	10R*	10R*	10R*	15R	15R		
<10R	<10R	30R*	30R*	10Re	10R*	10R*	15R*	15R	15R		
NO. 209 WINDOW FRAME SECTIONS											
0	0	0	0	0	0	0	0	0	0	0.67	Electro Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	<10R	0	0	0.24	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	3.10	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.61	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	<10R	0	30R	40R	60R	0	0	0.24	Cadmium Plated
0	<10Ra	10R	15R	0	<10R	<10R	10R	15Ra	25R		
<10Ra	15Ra	15Ra	20Ra	0	<10R	<10R	20R	<10R	<10R		
100Y	100Y	100Y	100Y	10Y	50Y	100Y	100Y	100Y	100nR	0.52	Electric Sherardized
100Y	100Y	100Y	10R - 90Y	10Y	50Y	100Y	100Y	100Y	100nR		
100Y	100Y	100Y	100Y	10Y	50Y	100Y	100Y	100Y	100nR		
<10Re	10R*	40R*	60R*	<10Re	15R	15R*	40R*	15R	15R	....	Amaloy
<10Re	10R*	40R*	60R*	<10Re	10R	15R*	50R*	15R	15R		
<10Re	20R*	40R*	60R*	<10Re	<10R	10R*	10R*	15R	15R		

TABLE V.—REPORT ON INSPECTION OF

Abbreviations and Symbols Used: 0 – no rust; 5, 10, 25, 100 – approximate percentages; R – rusting of bas
a – in angle; < – less than; e – edge;

Coating	Average Weight, oz. per sq. ft.	Exposure at Brunot Island, Pa.				Exposure at Altoona, Pa.			
		16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks
		NO. 792 WINDOW FRAME SECTIONS							
Electro Galvanized	0.54	0	15Ra	40Ra	50Ra	30Ra	50Ra	60R	70R
		0	10Ra	40Ra	50Ra	20Ra	50Ra	50R	70R
		<10Ra	40Ra	40Ra	50Ra	0	50Ra	50R	50R
	0.35	0	15Ra	50Ra	70Ra	<10Ra	30Ra	30R	70R
		<10Ra	25Ra	50Ra	70Ra	0	40Ra	50R	80R
		0	<10Ra	50Ra	70Ra	<10Ra	30Ra	40R	70R
Hot Dip Galvanized	2.60	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
Hot Dip Aluminum	1.30	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	0.22	<10R	40R	80R	100R	15Ra	60R	80R	100R
		0	15R	70R	90R	15Ra	60R	90R	100R
		<10Ra	40R	90R	100R	<10Ra	50R	90R	100R
	0.17	25Ra	75R	100R	100R	60R	90R	100R	100R
		25Ra	75R	100R	100R	50R	90R	100R	100R
		30Ra	80R	100R	100R	50R	75R	100R	100R
Electric Sherardized	0.57	20Y	20Y	<10R	10R	0	40Ys	40Y	40Y
		0	0	0	0d	0	0	0d	0d
		20Y	20Y	50Y	<10R	0	0	0d	0d
Gas Sherardized	0.58	100Ys	40Y	<10R	30R	100Ys	100Ys	0d	0d
		100Ys	40Ya	40Ya	20R	100Ys	100Ys	0d	15R
		100Ys	40Ya	40Ya	10R	100Ys	100Ys	0d	10R
Parkerized	....	0	40R*	50R*	100R	0	<10R	10R*	20R*
		0	20R*	30R*	100R	0	<10R	<10R*	20R*
		0	50R*	60R*	100R	0	<10R	<10R*	20R*
		NO. 161 WINDOW FRAME SECTIONS							
Electro Galvanized	0.89	<10Ra	40R	90R	95R	0	20Ra	40Ra	75Ra
		0	0d	30Ra	40Ra	0	20Ra	40Ra	75Ra
		0	10Ra	70Ra	70Ra	0	25Ra	40Ra	75Ra
	0.81	0	0d	20Ra	60Ra	0	10Ya	40Ya	60Ra
		0	10Ra	50Ra	70Ra	<10Ra	25Ra	30Ra	75Ra
		0	10Ya	40Ra	60Ra	0	15Ra	20Ra	75Ra
Hot Dip Galvanized	2.97	0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
		0	0	0	0d	0	0	0	0
Hot Dip Aluminum	0.66	0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
		0	0	0d	0d	0	0	0d	0d
Cadmium Plated	0.22	0	40R	100R	100R	50R	90R	100R	100R
		15Ra	90R	100R	100R	50R	90R	100R	100R
		20Ra	90R	100R	100R	50R	90R	100R	100R
	0.15	60R	100R	100R	100R	90R	95R	100R	100R
		60R	95R	100R	100R	80R	80R	100R	100R
		70R	95R	100R	100R	80R	90R	100R	100R
Electric Sherardize	0.32	0	0	0	10Y	0	0	0	0
		10Y	10Y	20Y	20Y	0	0	0	0
		0	0d	20Y	20Y	0	0	0	0
Gas Sherardized	0.42	50Y	100Y	100Y	100Y	<10R	<10R	<10R	<10R
		50Y	100Y	100Y	100Y	<10R	<10R	<10R	<10R
		50Y	100Y	100Y	100Y	<10R	<10R	<10R	<10R
Parkerized	....	100Y	100Y	90R	100R	0	<10R	<10R*	30R*
		100Y	100Y	80R	100R	0	<10R	<10R*	15R*
		100Y	100Y	90R	100R	0	<10R	<10R*	10R*

METALLIC COATINGS, ETC. (*Continued*).

metal; Y - yellow or orange alloy rust; * - rust spots widely distributed; d - black or dark surface film (soot or dirt); th - threads; n - near; s - stain.

Exposure at State College, Pa.				Exposure at Sandy Hook, N. J.				Exposure at Key West, Fla.		Average Weight, oz, per sq. ft.	Coating
16 Weeks	43 Weeks	68 Weeks	95 Weeks	17 Weeks	44 Weeks	69 Weeks	96 Weeks	52 Weeks	102 Weeks		
No. 792 WINDOW FRAME SECTIONS											
0	0	0	0	0	<10Ra	30Ra	30Ra	0	0	0.54	Electro Galvanized
0	0	0	<10Ra	0	<10Ra	30Ra	30Ra	0	0		
0	0	0	0	0	0	30Ra	30Ra	0	0		
<10Ra	<10Ra	<10Ra	<10Ra	0	<10Ra	20Ra	30Ra	25Ra	40Ra	0.35	
0	0	0	0	<10Ra	15Ra	20Ra	30Ra	10Ra	25Ra		
<10Ra	10R	10R	10R	<10Ra	20Ra	30Ra	40Ra	10Ra	20Ra		
0	0	0	0	0	0	0	0	0	0	2.60	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	1.30	Hot Dip Aluminum
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	<10Ra	20Ra	0	0	0.22	Cadmium Plated
0	0	0	0	0	0	<10Ra	20Ra	0	0		
0	0	0	0	0	0	<10Ra	40Ra	0	0		
10Ra	20Ra	30Ra	30Ra	20Ra	30Ra	40Ra	50Ra	30Ra	30Ra	0.17	
10Ra	10Ra	30Ra	30Ra	20Ra	30Ra	40Ra	50Ra	30Ra	30Ra		
10Ra	25Ra	30Ra	30Ra	20Ra	30Ra	40Ra	50Ra	20Ra	25Ra		
0	0	0	60Y	10Ys	<10Y	100Y	100Y	0	<10Y	0.57	Electric Sherardized
0	0	0	60Y	90Ys	<10Y	100Y	100Y	20Y	25Y		
0	0	0	60Y	75Ys	<10Y	100Y	100Y	25Y	25Y		
100Y	100Y	100aR	100aR	0	0	100Y	100Y	10R*	10R*	0.58	Gas Sherardized
100Y	100Y	100aR	100aR	<10Y	<10Y	100Y	100Y	20R*	30R*		
100Y	100Y	100aR	100aR	0	0	100Y	100Y	25R*	30R*		
0	40R	75R	90R	<10Re	20R	100R	100R	100R	100R	....	Parkerized
0	40R	75R	80R	<10Re	25R	100R	100R	100R	100R		
0	40R	75R	80R	<10Re	20R	100R	100R	100R	100R		
No. 161 WINDOW FRAME SECTIONS											
0	0	0	0	0	0	0	0	0	0	0.89	Electro Galvanized
0	0	0	0	0	<10Ra	<10Ra	10Ra	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0.81	
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	<10Ra	0	0		
0	0	0	0	0	0	0	0	0	0	2.97	Hot Dip Galvanized
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	<10R	<10R	0.66	Hot Dip Aluminum
0	0	0	0	0	0	0	0	<10R	<10R		
0	0	0	0	0	0	0	0	<10R	<10R		
0	10Ra	30Ra	35Ra	0	<10Ra	<10Ra	<10Ra	<10R	<10R	0.22	Cadmium Plated
0	0	0	0	<10R	<10R	<10R	10Ra	<10R	<10R		
0	0	0	<10Ra	0	10Y	40R	60Ra	<10R	<10R		
<10Ra	20Ra	50Ra	50Ra	<10R	<10R	75R	75R	75R	75R	0.15	
<10Ra	20Ra	50Ra	50Ra	20R	50R	75R	85R	50R	60R		
<10Ra	20Ra	50Ra	50Ra	20R	75R	75R	85R	75R	75R		
0	0	0d	30Y	0	0	20Y	60Y	15Y	15Y	0.32	Electric Sherardized
0	0	0d	50Y	0	0	10Y	10Y	10Y	10Y		
0	0	0d	75Y	0	0	20Y	50Y	...	...		
20Y	20Y	25Y	100Y	20Ya	80Y	90Y	100Y	<10Ra - 75Y	<10Ra - 90Y	0.42	Gas Sherardized
<10Y	30Y	80Y	100Y	15Ya	90Y	100Y	100Y	<10Ra - 75Y	<10Ra - 90Y		
<10Y	15Y	80Y	100Y	15Ya	90Y	100Y	100Y	<10Ra - 75Y	<10Ra - 90Y		
0	60R	90R	100R	<10R	50R	90R	100R	100R	100R	....	Parkerized
0	60R	90R	100R	<10R	50R	90R	100R	100R	100R		
0	60R	90R	100R	<10R	50R	90R	100R	100R	100R		

14 of the 1929 report of the subcommittee.[1] The metallic coatings on the specimens of hardware, structural shapes, tubular goods, etc., in these tests were furnished by a number of cooperating concerns, who were asked to apply metallic coatings representing their usual practice as to methods of application and weight. The results of the inspection of the specimens are shown in Table V, and should be interpreted in the light of the weights of metallic coatings shown by the determinations reported therein.[2]

ELECTROPLATED COATINGS

A special subcommittee has been organized to make a study of electroplated coatings as an extension of the present tests of plated coatings on hardware. This group is cooperating with the American Electroplaters' Society and the U. S. Bureau of Standards under the chairmanship of Mr. William Blum with Messrs. F. A. Hull, W. M. Phillips, A. K. Graham, L. H. Rovere, J. T. Hay and Phillip Sievering. The detailed program was discussed at a meeting in Chicago on January 16, 1931, and in Pittsburgh on March 19, 1931. The samples will consist of strips 4 by 6 in. plated with zinc, cadmium, copper, nickel, chromium or a combination of these metals. The coatings will be of known and approximately uniform thickness, and will be produced at the U. S. Bureau of Standards under defined conditions. Five samples of each kind will be exposed at Sandy Hook, N. J., State College, Pa., Pittsburgh, Pa., the Bell Telephone Laboratories in New York City, and the U. S. Bureau of Standards at Washington, D. C. Additional specimens will be simultaneously prepared for use in laboratory tests including stripping tests and accelerated exposures. About 7000 specimens will be required in all, of which number about 4000 specimens will be exposed.

This report was considered by the subcommittee at its meeting in Pittsburgh, Pa., on March 18, 1931, and was unanimously approved.

Respectfully submitted on behalf of the subcommittee,

F. A. HULL,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, pp. 151–158 (1929).

[2] Since its adoption at the annual meeting, this report has been slightly modified editorially respecting references to hardware, structural shapes, tubular goods, etc., in order to make clear that the tests refer to coatings and not to finished products.—ED.

REPORT OF SUBCOMMITTEE X ON EMBRITTLEMENT INVESTIGATION

1. *History:*

Galvanized structural steel is a material that has been used for engineering purposes for several decades. It is by nature a material which can stand considerable deformation. On rare occasions, however, galvanized structural steel has been known to break with a brittle fracture upon merely being subjected to impact. The serious results which may occur from the installation of this type of material have naturally caused some concern, but, due to its infrequent occurrence, no comprehensive investigation of the causes has heretofore been adopted.

In the development of the Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A.S.T.M. Designation: A 123 - 30) of the American Society for Testing Materials,[1] Technical Committee III on Structural Steel Shapes, Plates, Bars and Their Products of the Sectional Committee on Zinc Coating of Iron and Steel, functioning under the procedure of the American Standards Association, only casually discussed the desirability of an embrittlement clause in these specifications. The work of that committee was well under way when reports of serious failures of galvanized steel began to be received from various sources. Simmered down they all referred to a single job.

In August, 1927, a shipment of galvanized transmission tower steel was being unloaded in the Chicago district, when an angle fell from a railway car upon the ground and broke through some of the holes. Although open-hearth steel had been specified, subsequent chemical analysis of several samples of the lot indicated the presence of some heats of bessemer steel. The fabricator agreed with the purchaser to take every step possible to separate the bessemer steel from the open-hearth steel. The test devised was a simple angle bending test accomplished by inserting the end of an angle between the railroad ties and bending the angle over the rail. If it broke with a loud report and had no necking at the holes it was pronounced brittle steel. Many angles which broke in this manner were analyzed and it was soon determined that some showed a good open-hearth analysis. This opened up a new problem which had not developed previously.

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[1] **1930 Book of A.S.T.M. Standards, Part I, p. 284.**

The breaking test on the angles was performed on 10 per cent of all members and all such which showed definite crystalline fractures were discarded, and for those showing the most pronounced crystalline structure the whole heat rejected.

It was found that embrittled steel could be corrected by baking in an oven at about 300° F. for eight hours. Although bessemer steel was eliminated from this contract, it was also submitted to the baking process in order to determine whether bessemer steel which was embrittled could be corrected. These tests showed that bessemer steel so treated was satisfactory. All the steel which had been fabricated was baked in this manner, and subsequent tests made on the baked steel indicated that none of it remained embrittled.

The large size angles would still show a degree of embrittlement at the heel of the angle, but this was considered due to the fact that beyond the neutral axis this steel was subjected to a crushing fracture instead of tension, which thus showed as a granular fracture instead of a silky structure.

The question of steel embrittlement after this experience provided more discussions than any other single point in the development of specifications for galvanized structural steel. The galvanizers, who, in many cases have no direct connection with any steel producer, have been reluctant to accept responsibility for steel showing up as brittle under this angle bend test. Likewise, the steel makers have contended that the possibility of pickling brittleness is well known and has always been regarded as a problem for the galvanizer to take care of. Steel makers, however, have at no time defended the use of bessemer steel in galvanized transmission towers.

2. *The Extent of Our Present Knowledge:*

It is known that galvanized structural steel angles, such as those for transmission towers for example, have sometimes, though rarely, failed in a brittle manner in handling or in erection. There are verbal reports of embrittled steel, tough in the black but brittle on pickling and galvanizing, these reports being made in so circumstantial a fashion as to leave no doubt but that embrittled galvanized structural steel is an actuality. The appended bibliography includes numerous articles in American and foreign publications bearing on embrittling of steel in galvanizing and its causes.

Steel makers, galvanizers and fabricators state that there is such a thing, which they have either seen or heard of from entirely credible sources.

Oddly enough, none of the people who have met it appear to have retained a specimen, to say nothing of sufficient material for exhaustive study. Cases of brittle bolts and line hardware are more common. Cold heading or other severe forming operations not followed by annealing appear to explain such cases. Similarly, it is noteworthy that reports of embrittled angles refer to punched, that is cold-worked stock.

It does not appear to be as commonly recognized, though it should class as present knowledge, that in the few reported cases of embrittlement of angles, the tendency toward brittleness is accentuated as the thickness of the angle increases, that is, as the amount of cold work required to punch increases.

It appears to be accepted that bessemer steel is inherently too brittle for use in structural angles for such uses as transmission towers. Whether this need be true under all circumstances may be open to question, but commercial practice indicates unanimity of opinion.

It is common knowledge that the embrittlement phenomenon is but rarely met in open-hearth steel. A case has recently been reported in Germany and was characterized as very unusual. It is not known that this was open-hearth steel.

It is known that mild steel, cold deformed to some critical degree, and then heated to a temperature just below a visible red, is more brittle under notched-bar impact tests than the deformed material.

Heat treatment that wipes out the effect of cold working has a very pronounced effect in improving the ductility of structural steel as measured by impact tests.

At low temperatures, impact tests give lower values of energy absorbed than slow bending tests, whereas at higher temperatures (including room temperatures and somewhat above) the reverse is true.

The angle bend test is the test commercially considered to reveal the tendency toward embrittlement of transmission tower angles. It is not used for other purposes, and there are no published data in which it is used as a criterion for embrittlement. Almost all scientific work on the subject has been confined to the use of one form or another of the notched-bar impact test.

It is not common knowledge, but it is apparently true, that a steel may show a very fair notched-bar impact figure, but a poor angle bend test. The two types of test appear to show up somewhat different types of lack of toughness. The difference is probably due to the punching of the hole in the angle bend test.

It is common knowledge among those who have had occasion to use the angle bend test that, as now prescribed, the test is a rough one, depending too much upon the experience and personal equation of the observer.

It is known that hydrogen embrittlement due to pickling severely affects high-carbon steels, hard heat-treated steels, or steels hardened by cold working, and has a perceptible effect even on mild steel.

It is also known that the hydrogen escapes from an ungalvanized pickled steel with lapse of time at room temperature, and at a much more rapid rate as the temperature is raised, so that baking at a moderate temperature well below galvanizing temperatures removes the hydrogen and practically restores the toughness.

This brief summary of present knowledge makes no pretense of covering the scientific aspects of the problem. A critical summary of the pertinent articles in the literature has been prepared by Battelle Memorial Institute for the Utilities Research Commission.

3. *Theories as to Possible Causes:*

One theory as to the cause for reported failures is that while it was supposed that the material was open-hearth steel, it was actually bessemer that had been mixed in, in storage, or supplied in error, and that hence there is no real open-hearth problem.

Assuming, however, that open-hearth steel is really subject to embrittlement, the following theories are enumerated and discussed in the investigator's progress report:

1. Embrittlement may come primarily from hydrogen occluded in pickling;
2. Embrittlement may be due to work hardening in punching;
3. It may be essentially a precipitation hardening effect, arising from the temperatures used in hot galvanizing;
4. Embrittlement may be due to the built-up effect of a combination of causes, no one of which alone would be sufficient to impair the suitability of the metal.

4. *The Importance of the Problem to the Interests Involved:*

The investigation is one which is of widespread interest. The utilities and the carriers are concerned, due to their desire to obtain structural materials for electrical transmission purposes which are not subject to unlooked for failures and which have a low maintenance cost. The steel producers, galvanizers and fabricators wish to know the fundamental causes of the infrequently occurring embrittlement phenomenon and how to adjust their operations to avoid it. The zinc producers are interested to determine if galvanizing is a contributing cause and to eliminate undue failures, and insure satisfactory service from zinc-coated products.

5. *History of the Formation of Subcommittee X:*

Technical Committee III of the Sectional Committee on Specifications for Zinc Coatings of Iron and Steel proposed to the American Society for Testing Materials that it should undertake an investigation of the phenomenon of embrittlement of galvanized rolled structural steel. Supplementing this request from this committee, the A.S.T.M. received letters from the Bell Telephone Laboratories, Inc., the National Electric Light Association, the Commonwealth Edison Co., and a number of companies engaged in the galvanizing and fabrication of this material, requesting that this work be undertaken. Committee E-9 on Correlation of Research of the Society considered the request and concluded that the problem merited the study that had been proposed, and that the research should be conducted under the auspices of the Society's Committee A-5 on Corrosion of Iron and Steel. This matter was carefully considered by Committee A-5 at its meeting in Detroit, Mich., on March 20, 1930, and it was decided to organize a subcommittee to plan and direct the investigation. The statement of the desired activities of the investigation follows:

(*a*) To determine the causes of embrittlement encountered in hot-dip galvanized rolled steel;

(*b*) Depending upon the results of the research, to prepare specifications for material or treatment suitable for hot-dip galvanizing;

(*c*) To formulate a practical shop test for detecting embrittled hot-dip galvanized steel.

The groups selected to be represented on the subcommittee were: (1) steel manufacturers; (2) galvanizers and fabricators; (3) users, of which the public utilities were considered the largest and most interested; and (4) zinc manufacturers.

The galvanizers and fabricators held an informal meeting in Detroit, Mich., under A.S.T.M. auspices in March, 1930, and agreed to cooperate wholeheartedly in this work. They nominated as their representatives, H. O. Hill, Assistant Chief Engineer, McClintic-Marshall Co., and Thomas Gregory, Vice-President and General Manager, Hanlon-Gregory Galvanizing Co.

The National Electric Light Association formally appointed B. J. Barmack, Commonwealth Edison Co., Chicago, L. W. Codding, Public Service Electric and Gas Co., Newark, N. J., with C. E. Ambelang, Public Service Company of Northern Illinois, Chicago, and A. B. Campbell, Engineer, N.E.L.A. Headquarters, as alternates.

The manufacturers invited, and their representatives who accepted were: C. F. W. Rys, Carnegie Steel Co., Pittsburgh, Pa.,

E. F. Kenney, Bethlehem Steel Co., Inc., Bethlehem, Pa., and J. J. Shuman, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

C. S. Trewin of The New Jersey Zinc Co., New York, was invited and accepted to represent the zinc interests. V. F. Hammel accepted appointment as A.S.T.M. representative.

Subsequently, others solicited or were invited to membership, and the committee now is composed of the following:

C. E. Ambelang, Public Service Company of Northern Illinois
B. J. Barmack, Commonwealth Edison Co.
R. R. Bloss, International-Stacey Corp.
J. R. Brossman, General Electric Co., Works Laboratory
A. B. Campbell, National Electric Light Association
L. W. Codding, Public Service Electric and Gas Co.
J. D. Conover, The American Zinc Institute
B. F. Courtright, Wisconsin Steel Co.
J. H. Gibboney, Norfolk and Western Railroad
Thos. M. Gregory, Hanlon-Gregory Galvanizing Co.
V. F. Hammel, Electric Bond and Share Co.
H. O. Hill, McClintic-Marshall Corp.
W. G. Kelley, Utilities Research Commission
E. F. Kenney, Bethlehem Steel Co., Inc.
C. T. Ressler, Reading Iron Co.
C. F. W. Rys, Carnegie Steel Co.
J. J. Shuman, Jones & Laughlin Steel Corp.
C. S. Trewin, The New Jersey Zinc Co.

An organizing meeting was held in Pittsburgh, May 15, 1930, and the committee, now known as Subcommittee X on Embrittlement Investigation of Committee A-5 held its first meeting at Atlantic City, June 24, 1930. At the latter meeting a resolution was passed outlining that the project was believed to be warranted, and defining its scope thus:

> That it should include a study of the physical properties of structural steel as rolled, and after cold working, before and after hot-dip galvanizing, in order to determine the extent of the apparent embrittlement arising in the process with its cause or causes, and to recommend possible remedies and also propose suitable acceptance tests.

6. *Engagement of Battelle Memorial Institute:*

The committee early in its deliberations came to the conclusion that this problem could only be satisfactorily prosecuted by retaining a laboratory to carry on the investigation. After an inspection of the facilities of a number of laboratories it was the committee's decision to retain the Battelle Memorial Institute of Columbus, Ohio. On November 21, 1930, a meeting of the committee was held in Columbus, at which time the report of the special subcommittee delegated to study the laboratories was made, and approved by the committee as a whole, which authorized the formation of a Steering Committee to enter into a contract with Battelle Memorial Institute to carry on this work. H. W. Gillett, Director of the Battelle Memorial Institute was then invited to attend the committee meeting and he was informed as to the decision of the committee to retain his laboratory. At this time, a general inspection was made of the laboratory, and a formal contract was entered into.

7. *Cooperation of Utilities Research Commission:*

Active work on embrittlement of structural steel and hot galvanizing was started at Battelle by the Utilities Research Commission of Chicago, in July, 1930. The purpose of this investigation was very similar to that of the A.S.T.M., but since the companies represented in the Commission were consumers, their principal interest was in the method of testing and inspecting structural steels with reference to methods for determining their suitability for use in various types of services, and ultimately looking forward to specifications as a basis for purchasing. The A.S.T.M. committee early realized that there would be general criticism if there were a duplication of effort in the prosecution of the problem. Accordingly, the committee made arrangements with the officials of the Utilities Research Commission whereby they assented to the plan of engaging Battelle to prosecute the A.S.T.M. work, also invited them to cooperate in the work. It was the opinion of the Utilities Research Commission that inasmuch as their problem had already been started they did not think it advisable for them immediately to join with the A.S.T.M. committee, but they suggested that the work at Battelle be so arranged that the two problems would be handled in parallel, and that if at the completion of their first year's work, sufficient evidence were at hand to indicate the advisability of their joining with the A.S.T.M., they would do so. The work was therefore oriented so that methods of testing have been the principal subject of the investigation for the Utilities Research Commission; and field work in the collection of samples from the steel mills and testing of the samples in an endeavor to locate heats of steel which were particularly susceptible to embrittlement in pickling and galvanizing, has been the major work of the investigation for the A.S.T.M. These two phases are so closely intertwined that no attempt has been made to differentiate between them since the investigation is really a unit.

8. *Work Accomplished to Date:*

Supervision of the work of this investigation was placed in the hands of a Steering Committee consisting of J. J. Shuman, Chairman, C. F. W. Rys, H. O. Hill, W. G. Kelley (with the officers of the main committee, V. F. Hammel, and C. S. Trewin acting *ex-officio*), in order to facilitate the contact between the A.S.T.M. committee and Battelle Memorial Institute. The experimental work has been chiefly in the hands of S. Epstein, F. Sillers, Jr., B. N. Daniloff, and W. A. Welcker, Jr., with much help from a number of others of the Battelle staff, under the direct supervision of O. E. Harder and with constant advice from C. E. Williams and H. W. Gillett.

To date, 50 heats of steel have been quite thoroughly studied. These included 2 bessemer heats, 6 duplex, and 42 open-hearth. In practically every case the steel from the different heats was studied in different sizes of angles, ranging from 8 by 8 by 1 in. down to 2 by 2 by $\frac{3}{16}$ in. In addition to these 50 heats of steel, miscellaneous samples have been examined, including one angle which broke in an erection accident, angles from heats which had been rejected by inspection tests, miscellaneous pieces of line hardware, etc. In all, over 2000 separate tests have been made. The information obtained from the work on both of these investigations has been used as a basis for preparing the Progress Report.

In the last ten and one-half months, to May 15, during which time the study of embrittlement of structural steel in hot galvanizing has been going on at Battelle Memorial Institute, not a single failure of galvanized structural steel has come to our attention. In fact, authenticated information has been obtained of only one, this having taken place before the study started. If, then, the seriousness of the problem were to be judged from the number of failures which have occurred or come to light, the conclusion is rather reassuring.

On the other hand, any possibility whatever of failure due to brittleness will tend to shake confidence in the security of important galvanized structures. It has, moreover, been confirmed that in galvanized structural steel, factors may be present which can seriously impair the ductility. Indeed, the investigators have been led to the conclusion that the "typically" brittle material that has been reported, but of which it appears difficult to locate characteristic specimens, must be the product of several embrittling factors all working together.

A clear understanding of this problem and the significance of the results which have been obtained requires a knowledge of the factors which are involved and the meanings of various terms. It is axiomatic that a piece of steel will break when the total of all of the stresses exceeds the strength. Thus all operations which introduce stresses into the steel must be considered as contributing factors to embrittlement.

The first embrittlement factor is the chemical composition of the steel. This factor is very important, because it determines to a large degree the magnitude of all other factors. Thus the chemical composition of bessemer steel places it in quite a different class from open-hearth or electric-furnace steel, for example. With any given composition, however, there are certain operations which may introduce strains into the steel and, therefore, decrease the amount of externally applied stress required to cause fracture. Among these factors may be mentioned straightening, punching, pickling, galvanizing, etc.

The susceptibility to embrittlement by any one of these factors is the increase in brittleness or decrease in ductility due to the particular operation. As an illustration, the susceptibility to embrittlement in pickling and galvanizing is the increased brittleness resulting from these operations. Also the susceptibility to embrittlement by punching a hole in an angle is the increased brittleness resulting from a punched hole, as compared with a drilled hole or a subpunched and reamed hole. Likewise, the effect of testing temperature and other factors may be expressed in terms of susceptibility to embrittlement. In the final analysis, the brittleness of any steel is dependent upon the composition and the susceptibility to the various embrittling factors.

Due to the almost complete absence of failed material, a supply of commercial structural steel angles was obtained (bessemer steel being included) and subjected to various tests in the as-rolled, as-pickled, as-pickled and galvanized, and as-galvanized without pickling conditions, in order to detect and measure embrittlement effects of these various factors. Later, in field work in three steel plants an effort was made to locate a heat or heats of steel particularly susceptible to embrittlement, some 40 heats of steel being examined in the mills.

The tests which have been employed in this investigation included the angle bend test, in which the load is applied statically; the angle drop test, in which the load is applied suddenly; the hole tension test, in which a specimen cut from the angle is tested in tension after punching or drilling a hole in the center of the specimen; hole bend tests, in which the specimen is cut from the angle, the hole punched or drilled in the middle, and then subjected to bending; and impact tests including both Charpy and Izod specimens. An extensive study has been made of the relative effects of punched holes, as compared with drilled holes and subpunched and reamed holes.

Following this discussion of the objectives and progress, the Progress Report of Battelle Memorial Institute goes on at length with details of tests of a variety of types, and tentative conclusions reached therefrom at this stage of the investigation. The tests employed include samples tested at low and high temperatures; punched, subpunched and reamed, and drilled; as-rolled, pickled, pickled and galvanized, galvanized without pickling; cold-worked by compression; chemical determinations of oxygen, nitrogen, hydrogen, and other suspected elements. In these tests the comparison has been between open-hearth, open-hearth duplex, and bessemer steels, in angles of four representative sizes, and the investigator expresses the assurance that the right types of tests are being used to lead up to the answer upon the several phases of the subject that have come to the surface up to this time.

The heat effects are a promising field and the experiments point to the likelihood that galvanizing itself, independent of the effects of pickling, impairs the ductility of punched steel; also that some steels are more sensitive than others to this condition. This part of the research will require additional light. For the present the investigators find indications that both pickling and galvanizing are factors, independent of each other.

The effects of thickness are shown, and a further study should be made of the mechanics of punching and the extent of deformations around the holes.

The marked effects of low temperatures as so far studied point to the desirability of further experiments.

The data of these numerous tests have been presented to the subcommittee in the form of graphs, but with the stipulation that all of this material is tentative and subject to change or modification.

9. *Suggestions for Further Work by Battelle Memorial Institute:*

Battelle Memorial Institute's suggestions for a future program are as follows:

1. Inasmuch as a so-called "typical" open-hearth heat, which is said to be ductile in the black, and excessively brittle either as-pickled or as-galvanized, has not yet come to light, the field work should be continued in order to make further search for a steel more susceptible to the various embrittlement factors than any which have been investigated to date. In this connection, the work should

be made so extensive and so comprehensive that its quantitative results will earn prestige over previous investigations and over the various opinions that have been expressed so that it will be accepted by the engineers representing both the producers and consumers of structural steel.

2. Work on the effect of pickling and the susceptibility of structural steel to pickling embrittlement should be continued. This should include the effect of inhibitors in the pickling solution on the embrittlement of the pickled samples. The tests which have been made to date have in some cases been made in solutions containing an inhibitor and in other cases in solutions which did not contain an inhibitor. Heating to pickling temperatures without pickling needs study. Tests along this line should give valuable additional information regarding the magnitude of pickling as an embrittling factor.

3. More heats of duplex open-hearth steel should be studied, and the results correlated with the content of nitrogen and other elements.

4. Fully-killed open-hearth steel and steel in which phosphorus is intentionally added should be studied further.

5. The precipitation-hardening theory should be studied experimentally, using not only the notched-bar impact type of test, but also the angle bend or hole-tension type, and these tests should be made over a range of temperatures, especially at lower than atmospheric, and with various periods of room temperature and elevated-temperature aging. Some of this work is in progress, but it should be carried further, and broadened to include the effects of nitrogen, oxygen, phosphorus, carbon, etc. Special attention should continue to be given to the correlation between strain lines revealed by Fry's etching reagent and susceptibility to embrittlement.

6. A study of the mechanism of fracture should be given consideration.

7. Efforts to evaluate tests including tests of the angle bend type should be continued, though it is believed that very decided progress has already been made on this phase of the problem. The location of the hole in the angle bend test is one detail that needs more study.

8. Further study of the relation between cold working and susceptibility to embrittlement, is needed.

9. Recommended practices as to precautions in manufacture, pickling, galvanizing, punching, subpunching and reaming or drilling, should be drawn up, but not until further work can put such recommendations on a thoroughly sound and accepted basis.

10. Recommendations as to specifications and acceptance tests should be made, but only after sufficient experimental work has further clarified the problem.

10. *Recommendations of the Steering Committee:*

1. It is recommended that the work be continued until the end of June, 1932, in combination with the Utilities Research Commission as a joint project under the direction of the Steering Committee.

2. In order to continue the work as recommended it will be necessary to carry out the financial budget as originally outlined. The Utilities Research Commission has agreed to appropriate $4000, provided the subcommittee appropriates $12,000.

11. *Selected Bibliography:*

During the early part of the investigation, Messrs. S. Epstein and B. N. Daniloff of Battelle Memorial Institute, made a very detailed review of the literature and prepared a selected bibliography on the problem of the embrittlement of structural steel in galvanizing, for the Utilities Research Commission. The primary purpose of this review was to find whatever clues the literature might contain to a readily practicable solution of the problem of brittleness in galvanized structural steel. From the beginning a sharp lookout was kept for description of actual instances of embrittlement of galvanized structural steel. As a matter of fact, no details as to such particular cases were found, although the general subject of the embrittlement of steel in galvanizing was frequently mentioned. Likewise, no definite data were found to bear on the effect of the melting process on embrittlement, except for the detrimental influence of phosphorus, which is always high in bessemer steel. It would seem, therefore, that the procurement of such data has to depend on the investigators' own efforts in this study.

On the other hand, the general subject of the embrittlement of steel is covered by an extremely voluminous literature, some of it dealing with matters directly applicable to our problem, and the rest of more indirect import. Since reading the literature, as contrasted with experimenting, is comparatively inexpensive, the scope of the review was not limited too closely, and a fairly broad survey of the field was made. Over two hundred references were collected and consulted, and about one-half of these articles (a good proportion of them in German and French) were carefully read and abstracted. No attempt was made, however, to make the review exhaustive, as to do so would have been practically impossible in any reasonable time. Some of the references which were not gone over carefully will be read and abstracted as the study continues.

In the selected bibliography appended hereto, the references have been arranged according to the headings indicated. The references under the various headings are arranged chronologically.

Acknowledgment:

Grateful acknowledgment is made to F. Sillers, Jr., much of whose report material is recorded herein verbatim, others digested to conform with the committee's views of the situation.

Acknowledgment is also made to the following firms who generously cooperated with Battelle Memorial Institute in providing materials, etc.: Carnegie Steel Co., Illinois Steel Co., International-Stacey Corp., Jones & Laughlin Steel Corp., Joslyn Manufacturing Co., Ohio State University, McClintic-Marshall Co., and the Wisconsin Steel Co.

The committee wishes also to take this opportunity to thank the following who contributed substantially to defray the expense of this investigation.

American Bridge Co.
American Zinc Institute
Bessemer Galvanizing Works
Bethlehem Steel Co., Inc.
Blaw-Knox Co.
Carnegie Steel Co.
Diamond Expansion Bolt Co.
General Electric Co.
Hanlon-Gregory Galvanizing Co.
Illinois Steel Co.
International Stacey Corp.
Jones & Laughlin Steel Corp.
Joslyn Manufacturing and Supply Co.
Lehigh Structural Steel Co.
McClintic-Marshall Co. (remitted by Bethlehem)
Muskogee Iron Works
National Electric Light Assn.
Newport News Shipbuilding and Dry Dock Co.
Pacific Coast Steel Corp.
The Parkersburg Rig and Reel Co.
Pittsburgh Screw and Bolt Corp.
Pittsburgh Steel Co.
Railway and Industrial Engineering Co.
Reading Iron Co.
Tennessee Coal, Iron and Railroad Co.
Utilities Research Commission, Inc.
Wisconsin Steel Co.
Youngstown Sheet and Tube Co.

This report was unanimously adopted by the subcommittee at its meeting in Chicago on June 23, 1931.

Respectfully submitted on behalf of the subcommittee,

V. F. Hammel, *Chairman.*
C. S. Trewin, *Secretary.*

Steering Committee
Jesse J. Shuman, *Chairman*
H. O. Hill
W. G. Kelley
C. F. W. Rys

APPENDIX

SELECTED BIBLIOGRAPHY

ON THE

EMBRITTLEMENT OF STRUCTURAL STEEL IN GALVANIZING

By Samuel Epstein[1] and B. N. Daniloff[1]

PREPARED UNDER THE SPONSORSHIP OF THE UTILITIES RESEARCH COMMISSION OF CHICAGO, ILL. REVISED FOR SUBCOMMITTEE X OF COMMITTEE A-5 ON CORROSION OF IRON AND STEEL OF THE AMERICAN SOCIETY FOR TESTING MATERIALS.

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REPORT OF SECTIONAL COMMITTEE
ON
ZINC COATING OF IRON AND STEEL

The sectional committee held two meetings during the past year, on October 23, 1930, in New York City and on March 19, 1931, in Pittsburgh, Pa., and submits the following report of its activities:

The meeting on October 23, 1930, was a special meeting called for the purpose of considering the recommendation of Technical Committee II on Sheets and Sheet Products that the Standard Specifications for Zinc-Coated (Galvanized) Sheets (A 93 – 27) of the American Society for Testing Materials be submitted to the American Standards Association for approval as American Tentative Standard. This recommendation was approved at the meeting and on November 6, 1930, was referred to letter ballot of the sectional committee. The vote of the sectional committee on this recommendation resulted in 38 affirmative and 1 negative votes and 6 members marked their ballots "not voting." The specifications were accordingly submitted by the sectional committee through its sponsor the American Society for Testing Materials to the American Standards Association on March 4, 1931, together with an accompanying report covering the history of these specifications. These were approved as American Tentative Standard on June 20, 1931, the A.S.A. designating number being G 8b 1–1931.

At the October meeting, the sectional committee also decided to request the A.S.T.M. to withdraw from their publications the Proposed Specifications for the Zinc-Coating on Iron and Steel Sheets which were accepted by the Society two years ago for publication as information.

Technical Committee I on Hardware and Fastenings (A. L. Fox, chairman).—The activities of Technical Committee I during the past year have been directed toward the collection of representative samples of commercial zinc-coated products, and their laboratory analysis to determine weight and uniformity of coating. This work has now been practically completed and a tentative draft of specifications for hot-dipped galvanized hardware products has been distributed to the members of the committee and were discussed at the recent meeting in Pittsburgh. These specifications will be redrafted and redistributed to the technical committee for comment and will be recommended to the sectional committee for approval as a proposed tentative standard.

It is expected that the activities of the technical committee during the coming year will include the preparation of specifications for sherardized, electro-galvanized, and Schoop process coatings.

Technical Committee III on Structural Steel Shapes, Plates, Bars and Their Products (V. F. Hammel, chairman).—Technical Committee III held only one meeting during the past year, a joint meeting with Subcommittee X on Embrittlement Investigation of Committee A-5 on Corrosion of Iron and Steel of the American Society for Testing Materials. This committee is conducting at the Battelle Memorial Institute a study of the embrittlement of structural steel in the galvanizing process. A report of progress was submitted by H. W. Gillett of the Battelle Memorial Institute covering their investigations to date.

The revised Standard Specifications for Zinc (Hot Galvanized) Coatings on Structural Steel Shapes, Plates and Bars and Their Products (A 123 – 30)[1] which were adopted by the sponsor body, the American Society for Testing Materials, last year were subsequently referred to the American Standards Association and on December 31, 1930, were approved as American Tentative Standard with the A.S.A. No. G 8c – 1930.

Copies of the revised standard specifications together with the 1930 report of the technical committee were sent to a number of companies in England and Germany that are galvanizing structural steel, with the request that they forward any criticisms or comments on the specifications that they may have to offer. Only a few replies have been received so far but this information will be summarized for the committee at a later date.

Technical Committee IV on Pipes, Conduits and Their Fittings (C. J. Krieger, chairman).—The fourth draft of the proposed specifications for zinc-coatings for iron on steel pipe and fittings prepared by Technical Committee IV was issued in April, 1928, for information and comment. No criticisms, adverse or otherwise, had been received so, during the past year, the members of the committee were asked to vote on the recommendation that these specifications be presented to the sectional committee for its approval. The necessary affirmative vote was not received.

In view of this, and also of the fact that one of the member bodies of the American Standards Association will shortly present its standard on rigid conduit to the A.S.A. under the proprietary standards method, the sectional committee voted to withdraw electrical conduit from the scope of this technical committee, thus confining its activities to pipes and fittings only. It was also voted that this committee reorganize its personnel to bring it up to date and to make it consistent with its new scope.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 284.

Technical Committee V on Wire and Wire Products (J. L. Schueler, chairman).—The various specifications drafted by this technical committee in conjunction with Subcommittee VI on Specifications for Metallic Coated Products of the A.S.T.M. Committee A-5 on Corrosion of Iron and Steel have all been adopted as A.S.T.M. standards. Consideration has been given to submitting the Standard Specifications for Zinc-Coated (Galvanized) Steel Wire Strand (A 122 - 30) to the American Standards Association for approval as American Tentative Standard. Objections have been raised to these specifications as a result of which a special subcommittee has been organized to give them further study.

In view of the objections raised concerning the galvanized strand specifications, another special subcommittee was formed to study other specifications for galvanized wire prior to their being submitted to the A.S.A. for approval. Both of these special subcommittees are expected to report at a meeting of the committee to be held during the annual meeting of the American Society for Testing Materials in June.

Technical Committee VII on Methods of Testing (E. S. Taylerson, chairman).—Since the reorganization of committee activities reported last year, this committee has been mostly concerned in determining the demand for new investigations and methods of testing.

The research committee is still considering the possibility of developing a laboratory test which will predict service in the atmosphere. Its work is still confined to the simulated industrial atmosphere test, although the influence of salt spray is also under consideration. The apparatus employed is both elaborate and expensive and the program already under way will probably not be completed for several years. The progress to date has not been encouraging although a large amount of work has been accomplished. The difficulty is not entirely due to design and operation of apparatus to enable consistent results to be obtained, but also involves the great variation in corrosion rate encountered in actual atmospheric exposure tests at different locations. It may be necessary to develop apparatus of a more flexible nature in which it will be possible to so vary the influence of a number of corroding agents as to duplicate a particular atmospheric condition. Very little is known of the essential differences in climate encountered in the atmospheric tests of Subcommittee VIII on Field Tests of Metallic Coatings of the A.S.T.M. Committee A-5 on Corrosion of Iron and Steel.

A committee under the chairmanship of Mr. F. M. Crapo is studying the present Methods of Determining Weight of Coating on Zinc-Coated Articles (A 90 – 30). An extensive comparative study has been made of the hydrochloric acid - antimony chloride and the dilute sulfuric acid methods which indicates excellent consistency. Difficulties have been experienced in interpreting the Preece test for wire, hardware, and pipe which has led to the appointment of a special subcommittee under the chairmanship of C. C. Crane, to study the specifications, limitations, and interpretation of the Preece test.

This report has been submitted to letter ballot of the sectional committee, which consists of 48 members; 36 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the sectional committee,

J. A. Capp,
Chairman.

A. B. Campbell,
Secretary.

REPORT OF COMMITTEE A-6
ON
MAGNETIC PROPERTIES

One meeting of Committee A-6 on Magnetic Properties was held during the past year, in March at Pittsburgh, Pa., in connection with the Spring Group Meeting of A.S.T.M. Committees.

At the meeting of the committee held in Pittsburgh, the following motion was adopted by the committee:

Moved that Committee A-6 on Magnetic Properties of the American Society for Testing Materials concludes, after careful consideration, that there is no important need in the field of industry and science represented by this committee, for the series of magnetic units proposed by the Subcommittee on Magnetic Units of the U. S. National Committee of the International Electrotechnical Commission in its report circulated under date of February 16, 1931, to the members of the U. S. National Committee; further, that Committee A-6, in view of the increase in complexity that would result from the addition of this new series of units to those now most generally employed and in view of the probable confusion that would thereby be entailed, strongly opposes the adoption of the proposed units; further, that the chairman of this committee is directed to transmit the substance of this motion to the various members of the U. S. National Committee.

Space Permeability.—It was voted that the secretary be instructed to report to the chairman of the subcommittee, of the Sectional Committee on Definitions of Electrical Terms, Mr. H. L. Curtis, the committee's recommendation that the symbol μ_0 be used to designate initial permeability rather than space permeability, as proposed by the subcommittee of the sectional committee.

Mr. F. H. Allison, Jr., of the Crucible Steel Co. has been appointed as the representative of A-6 on the general Membership Committee of the Society.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Definitions and Nomenclature (W. J. Shackelton, chairman).—In view of the adoption by the International Electrotechnical Commission of the name "oersted" for the unit of magnetic force, the subcommittee recommends the Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 30 T) be revised so as to conform to this action. This would leave the unit of magnetic reluctance without a name and substitute "oersted" for "rowland" as the name of the unit of magnetic force.

A Sectional Committee on Definitions of Electrical Terms under the procedure of the American Standards Association is very actively engaged in preparing a comprehensive set of definitions including "magnetic." It is believed that these will be available within the next year. It was therefore recommended that the present list of definitions as amended be continued as tentative, so that when advanced to standard they can be brought into accord with the definitions developed by the sectional committee. Committee A-6 will be kept in close touch with the progress, since it has a representative on the sectional committee.

The subcommittee also called to the attention of Committee A-6 the proposal of the Subcommittee on Magnetic Units of the U. S. National Committee of the I.E.C. that a series of so-called "practical" magnetic units be adopted, and recommended that Committee A-6 go on record as strongly opposing such action.

The subcommittee also raised objection to the proposed use of the symbol μ_o to denote "space permeability," as previously mentioned, in the belief that this symbol should be retained to denote "initial permeability," especially since this use has become fairly common in the technical literature.

Subcommittee II on Alternating Current Tests at Low Inductions (R. L. Sanford, chairman).—Since the report of a year ago, additional checks have been made on the series of ring samples of ferro-magnetic materials supplied by the Bell Telephone Laboratories. The results check so well that the subcommittee believed that it was time to prepare a set of tentative procedures for low induction tests, specifying the Owen bridge method and the alternating current potentiometer method as alternative methods. Such a set of specifications has been prepared, the details of which are given later in this report.

Subcommittee III on Tests at High Magnetizing Forces (L. E. Howard, chairman).—A number of investigators have made further tests at high magnetizing forces by different methods and with a number of check samples. In view of the results obtained, the subcommittee recommended that the "J-permeameter" be designated the "Babbitt permeameter" in honor of its inventor, and added to the list of approved instruments for measurements with magnetizing forces above 40 oersteds.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Proposed Revision of Tentative Standard.—The committee recommends that the Tentative Definitions of Terms, with Units and

Symbols, Relating to Magnetic Testing (A 127 – 30 T)[1] be revised by omitting the name "oersted" for the unit of reluctance and substituting "oersted" for "rowland" as the name of the unit of magnetic force. The committee also recommends that the list of definitions as thus revised be continued as tentative pending the completion of a list of definitions of magnetic terms by the Sectional Committee on Definitions of Electrical Terms functioning under the American Standards Association.

Proposed Tentative Revision of Standard.—The committee has prepared a proposed revision of the test procedure for properties at low inductions and audio frequencies described in Sections 14 to 19 of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28).[2] The proposed revision, which is appended hereto,[3] includes the Owen bridge method and the alternating-current potentiometer method as alternative test procedures. The committee recommends that this revision be published as tentative to supersede when adopted Sections 14 to 19 of Standard Methods A 34 – 28.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF TENTATIVE STANDARD			
Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 30 T)..	13	0	2
II. PROPOSED TENTATIVE REVISION OF STANDARD			
Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 28)........	13	0	2

This report has been submitted to letter ballot of the committee, which consists of 15 members; 13 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

EDITORIAL NOTE

The proposed revision of the Tentative Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing was accepted. The definitions in their revised form appear on page 696.

The proposed revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel was accepted for publication as tentative and appears on page 1045.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 983 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 80.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 396.

[3] See p. 1045.—ED.

REPORT OF COMMITTEE A-8
ON
MAGNETIC ANALYSIS

The investigation on the relation of magnetic properties and toughness as indicated by the results of impact tests has been completed under the auspices of Subcommittee I on Impact Tests, under the chairmanship of Mr. Haakon Styri. The results of this investigation were discussed at a meeting of the committee held in conjunction with the A.S.T.M. Group Meeting of Committees in Pittsburgh, Pa., on March 19, 1931. The formal report to the Society on this investigation will appear as a technical paper by Mr. Styri, entitled "Relation Between Magnetic Properties, Impact Strength and Hardness" and will be presented at this annual meeting of the Society.[1]

Plans are under way for undertaking two new projects. One is the preparation of a series of critical abstracts of articles bearing on the subject of magnetic analysis. The other is the collection of data on the magnetic properties of several series of commercially important steels together with such other data as can readily be obtained on magnetic test specimens. These data should serve as a valuable foundation for investigations in the field of magnetic analysis.

The committee continues to serve as a clearing house for the interchange of data and experience among its members and this is probably one of its most valuable functions.

This report has been submitted to letter ballot of the committee, which consists of 16 members; 14 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

R. L. Sanford,
Chairman.

A. V. de Forest,
Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 94 (1931).

REPORT OF COMMITTEE A-10

ON

IRON-CHROMIUM, IRON-CHROMIUM-NICKEL AND RELATED ALLOYS

Since the annual meeting of the Society last June, Committee A-10 has held one meeting in Pittsburgh, Pa., March 17, 1931, during the Spring Group Meeting of A.S.T.M. Committees. Although still a fact-finding and research group, attention is now being directed to standardization of some of the most widely used alloys falling within its scope. A specifications subcommittee has been authorized but its organization has not yet been completed. The present membership of the committee is 47: one new member (consumer) having been added during the past year and one member having resigned.

GENERAL COMMITTEE ACTIVITIES

After a study of the subject, Subcommittee II on Nomenclature, under the Chairmanship of Mr. T. H. Nelson was disbanded, on vote of the members of Committee A-10 during the meeting held in Pittsburgh. This subcommittee had under consideration a classification of the various alloys but the wide use of trade names in advertising makes it impossible to use a classification system for alloys at the present time. It was felt by the committee that industrial concerns would not readily accept a classification of alloys and the subject has been temporarily dropped.

Mr. I. B. McCorkle was appointed Chairman of Subcommittee V on Mechanical Testing, and the Fact-Finding Committee on Welding was replaced by a Subcommittee on Welding, under the chairmanship of Mr. F. B. Olcott.

Because of the widespread use of certain of the alloys in exposed parts of structures and machines, weather exposure tests simulating the atmospheric corrosion tests being conducted by Committee A-5 on Corrosion of Iron and Steel are being considered.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Classification of Data (Jerome Strauss, chairman).—The Tables of Chemical Compositions, Physical and Mechanical Properties and Corrosion-Resistant Properties of Corrosion-Resistant and Heat-Resistant Alloys were completed by the subcommittee subsequent to the presentation of the 1930 report and have been published in Part I of the 1930 Proceedings in the form of insert tables designated Plates V to XV. Copies of the tables were also published under a separate binder and about 2000 copies distributed in this form. Certain additional information regarding alloys of other manufacturers, not available at the time the original data was accumulated, will be included in the next printing of the tables.

Subcommittee III on Methods of Chemical Analysis (F. B. Foley, chairman).—One meeting of this subcommittee has been held. The need for a reliable standard has been pointed out, especially for the 18 per cent chromium, 8 per cent nickel alloy of various carbon contents. It is the aim of the subcommittee to approach the U. S. Bureau of Standards through Mr. G. E. F. Lundell to have suitable standard samples prepared and to cooperate with Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, which has already prepared methods of analysis for somewhat similar materials. The preparation of standard methods of analysis must necessarily be deferred until suitable standard samples are available.

Subcommittee IV on Methods of Corrosion Testing (W. R. Huey, chairman).—The collaborative corrosion testing program undertaken by this subcommittee is being carried out by fifteen laboratories. Four of the laboratories have completed the acid immersion and copper sulfate stain tests and most of the others have these tests in various stages. The salt spray test has been delayed until all of the control specimens being prepared by the Naval Gun Factory are in the hands of the various laboratories. These specimens have been made and shipped to the laboratories within the past two weeks. About eight of the cooperating laboratories have been visited by the chairman and considerable correspondence has been necessary in settling questions regarding procedure. The balance of the laboratories will be visited in the near future.

It will be possible to report substantial progress in the testing program at the June meeting. All tests should be completed by autumn and the final report for this phase of the work certainly will be complete before the end of the year.

Subcommittee V on Mechanical Testing (I. B. McCorkle, chairman).—The chairmanship of this subcommittee was just recently accepted by Mr. McCorkle, but the complete personnel is not yet available. The work of the subcommittee will consist essentially of a study of methods for the determination of elastic and impact properties of alloys coming within the scope of Committee A-10.

Subcommittee VI on Metallography (N. L. Mochel, chairman).—Subcommittee VI will probably study grain-growth and embrittlement of low-carbon plain chromium steels on exposure to elevated temperatures; also, etching reagents which will prove most generally useful in micrographic and macrographic inspection.

Subcommittee VII on Welding (F. B. Olcott, chairman).—This subcommittee has replaced the Fact-Finding Committee on Welding which was composed of Messrs. P. D. Merica, C. E. McQuigg, F. B. Olcott, and T. H. Nelson. The subcommittee plans to devote one year to determining if information of value in the field of welding can be obtained. The membership of the subcommittee is undetermined at this time; however, those interested are invited to discuss the subject with the chairman.

This report has been submitted to letter ballot of the committee, which consists of 47 members; 32 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

JEROME STRAUSS,
Chairman.

H. D. NEWELL,
Secretary.

REPORT OF RESEARCH COMMITTEE
ON
FATIGUE OF METALS

During the past year, the Research Committee on Fatigue of Metals held one meeting in Pittsburgh on March 17, 1931. At this meeting, Mr. F. F. Lucas of the Bell Telephone Laboratories showed some photographs of martensite with a magnification of 3500 diameters which showed many extremely small cracks in certain structures. This was interesting evidence, especially in connection with the work of such physicists as Griffiths[1] and Zwicky[2] who have suggested the policy that even in sound metals there are thousands of minute cracks whose width is measured in atoms.

Another interesting suggestion, which was brought forward by the chairman as a result of a study of railroad rails under wheel loads, was that a stress of a given magnitude at the surface of a specimen may be more dangerous as a potential cause of a spreading fatigue crack than a stress of the same magnitude in the interior of a piece of metal.

The summary "Present-Day Experimental Knowledge and Theories of Fatigue Phenomena in Metals," prepared by the committee and published in the 1930 report,[3] is by no means complete and the committee is now engaged in preparing summaries of present-day knowledge of corrosion-fatigue and of the significance of fatigue to the designers and users of structures and machines, including a study of the conditions under which fatigue (spreading fracture) is not a significant factor.

The committee has continued the preparation of abstracts of important publications and technical articles, both in this country and abroad, dealing with fatigue of metals. The second set of abstracts of articles appearing in the technical press from July 1, 1929,to June 30, 1930, was issued in pamphlet form in the fall of 1930. The committee plans to continue preparation of such abstracts from time to time to supplement those already issued.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

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[1] A. A. Griffiths, "Phenomena of Rupture and Flow in Solids," *Transactions*, Royal Soc. of London, Vol. 221, A, p. 163 (1920).

[2] F. Zwicky, "On the Imperfections of Crystals," *Proceedings*, Nat. Academy of Sciences, Vol. 15, No. 11, March, 1929, p. 253; also "On Mosaic Crystals," *Proceedings*, Nat. Academy of Sciences, Vol. 15, No. 11, p. 816, November, 1929.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 260 (1930).

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS

Proposed New Tentative Standard.—The committee recommends that the proposed Tentative Methods of Chemical Analysis of Silver Solders, appended hereto,[1] be accepted for publication as tentative.

In the Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19),[2] the committee proposes the following editorial change: Under Determination of Copper by the Electrolytic Method, change the eighth sentence under Method to read as follows, by the addition of the italicized words and the omission of those in brackets:

> For each solution use a current *density* over night of 0.5 ampere [at approximately 10 volts] *per square decimeter* (*4.5 amperes per square foot*), or [else] use a current *density* of 4 amperes [at approximately 10 volts continued] *per square decimeter* (*36 amperes per square foot*) for [about] 2½ hours.

The committee also recommends a similar editorial change in the Standard Methods of Battery Assay of Copper (B 34 – 20)[3] under Assay of Electrolytic and Low-Resistance Lake Copper in the second sentence of the second paragraph under Method.

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Pure Metals in Ingot Form (W. H. Bassett, chairman).—This subcommittee recommends that the Tentative Specifications for Fire-Refined Copper Other than Lake (B 72 – 28 T) be continued as tentative pending adjustment of the criticized limits for selenium and tellurium.

Subcommittee VII on Methods of Chemical Analysis (H. V. Churchill, chairman).—This subcommittee has studied the methods for analysis of silver solders, and is recommending for publication as tentative, as appended hereto,[1] proposed Tentative Methods of Chemical Analysis of Silver Solders.

This subcommittee is also studying analyses of the metals in the following standards and tentative standards:

1. Determination of Tin in Aluminum-Base Alloys (B 40 – 28 T);
2. Analysis of Phosphor Tin (B 51 – 27);

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[1] See p. 722.—Ed.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 813.

[3] *Ibid.*, p. 776.

3. Analysis of Phosphor Copper (B 52 – 27);
4. Analysis of Silicon Copper (B 53 – 27);
5. Analysis of Brazing Solder (B 64 – 28);
6. Analysis of Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 30 T); and
7. Analysis of Manganese Bronze (B 27 – 19).

The subcommittee recommends that Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 28 T) be continued as tentative for another year pending the inclusion of the method for tin mentioned above.

After studying the wording of the Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19) and the Standard Methods of Battery Assay of Copper (B 34 – 20) which refers to the amperage and voltage to be used in electrolyzing copper, the subcommittee is modifying the present wording as given in detail earlier in this report.

The recommendation appearing in this report has been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARD			
Tentative Methods of Chemical Analysis of Silver Solders	54	0	12
II. EDITORIAL REVISIONS OF STANDARD METHODS			
Standard Methods of Chemical Analysis of Manganese Bronze (B 27 – 19)	51	2	13
Standard Methods of Battery Assay of Copper (B 34 – 20)	54	2	11

This report has been submitted to letter ballot of the committee, which consists of 104 members; 73 members returned their ballots, of whom 65 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

WILLIAM CAMPBELL,
Chairman.

E. E. THUM,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Chemical Analysis of Silver Solders were accepted for publication as tentative and appear on page 722. The proposed revisions of the Standard Methods of Chemical Analysis of Manganese Bronze and Methods of Battery Assay of Copper were approved as editorial changes.

REPORT OF COMMITTEE B-3
ON
CORROSION OF NON-FERROUS METALS AND ALLOYS

During the past year Committee B-3 has made progress as indicated in this report.

A number of test specimens were improperly machined by a commercial machine shop with the result that some replacements of materials and specimens had to be made. This has delayed the entire program of the committee. The new materials, however, are now available and no further delays are anticipated.

The committee has considered a proposal that it undertake periodically the preparation of critical review of the literature on corrosion of non-ferrous metals and alloys. It is felt that such a review would be very desirable but that it would be too large an undertaking for this committee. It should be the task of a separate permanent organization with sufficient financial backing to employ the necessary help.

A special subgroup made a study of the various units used for expressing rate of corrosion and found that if values in the literature were all given in certain uniform units it would considerably facilitate the reading and correlation of data. Committee B-3, therefore, recommends to other committees of the Society and to research workers in general the following two units:

1. Milligrams loss per square decimeter per day;
2. Inches penetration per year.

The committee wishes to call attention to the very commendable accumulation of information contained in the Tables of Chemical Compositions, Physical and Mechanical Properties and Corrosion-Resistant Properties of Corrosion-Resistant and Heat-Resistant Alloys appearing in the 1930 *Proceedings*[1] and published in pamphlet form by the Society.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee VI on Atmospheric Corrosion (W. H. Finkeldey, chairman).—This subcommittee decided to drop the indoor test program and erect two additional racks outdoors. Recent investigations by the telephone companies operating on the Pacific Coast between San Diego and Los Angeles show this area to be one having a relatively high humidity and heavy dew fall. Even in localities entirely free from industrial plant contamination the atmosphere is found to be very corrosive. The test conditions here would be entirely different from either of the other two sea coast locations of the committee. One of the additional racks will be placed in this area and the other in a dry location.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, Plates V to XV (1930).

Permission has been secured from the Central Arizona Light and Power Co. of Phoenix, Ariz., through the cooperation of Mr. E. H. Coe, Vice President and General Manager, to erect a test rack on one of the company's properties at Phoenix. The erection of the supporting rack and the installation of the test specimens will be under the supervision of Mr. L. K. Doutrick, Chief Engineer, who will be the subcommittee's representative at this location.

The subcommittee was fortunate in having the assistance of Mr. H. W. Hitchcock, Chief Engineer of the Southern California Telephone Co., Los Angeles, Calif., in finding a suitable test site in the seacoast district where past experience of the utility companies indicated very severe corrosion could be expected. After considering several locations Mr. Hitchcock and his assistant, Mr. R. H. Berggren secured permission from the University of California for the committee to erect a test rack on the property of the Scripps Institution of Oceanography at La Jolla, Calif. This location is within a few hundred feet of the ocean and should be a most severe seacoast exposure. Mr. Berggren will supervise the installation of the rack and test specimens and will act as the subcommittee's representative at this location.

The subcommittee wishes to express its appreciation for the cooperation secured from both of these companies and also to thank those mentioned above for their very helpful assistance in starting these tests and for their keen interest in the test program.

Subcommittee VIII on Galvanic and Electrolytic Corrosion (C. L. Hippensteel, chairman).—This subcommittee by agreement with Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys is including in its test program stainless steel in contact with various non-ferrous metals.

This report has been submitted to letter ballot of the committee, which consists of 42 members; 36 members returned their ballots, of whom 35 have voted affirmatively, and none negatively.

Respectfully submitted on behalf of the committee,

T. S. FULLER,
Chairman.

SAM TOUR,
Secretary.

REPORT OF COMMITTEE B-4

ON

ELECTRICAL-HEATING, ELECTRICAL-RESISTANCE AND ELECTRIC-FURNACE ALLOYS

One meeting of Committee B-4 has been held during the year, on February 16 and 17, 1931, in New York City. A second meeting will be held prior to the presentation of this report to the Society at which time the report will be reviewed and other matters considered.

Three members have been added to the committee during the year, leaving the total membership 30, classified as 15 consumers, 12 producers and 3 general interests.

In 1929, at the request of manufacturers of electrical heating and electrical-resistance wires, Committee B-4 prepared a list of colors for the labels to be used on spools of wire to identify the different grades. This list has been accepted by the wire manufacturers. Since that time, a request has been received to extend the list to include other grades of wire. The matter was referred by the committee to the Coordinating Committee on Non-Ferrous Metals and Alloys which has authorized Committee B-4 to proceed with further assignments of colors. Accordingly a Subcommittee on Label Colors has been appointed.

Mr. C. L. Clark has been appointed chairman of Subcommittee V in place of Mr. H. W. McQuaid who resigned on account of pressure of other work.

Mr. Gordon Thompson has been appointed to serve as the representative of Committee B-4 on the General Membership Committee of the Society.

RECOMMENDATIONS AFFECTING TENTATIVE STANDARDS

Proposed Tentative Standards.—The following proposed specifications for alloys for use as electrical heating elements are recommended for publication as tentative standards as appended hereto:[1]

Proposed Tentative Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements.

Proposed Tentative Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, Balance Iron, for Electrical Heating Elements.

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[1] See pp. 708 to 715.—ED.

A proposed Tentative Method of Test for Determining the Temperature-Resistance Constants of Resistance Alloys is also recommended for publication as tentative as appended hereto.[1] This test provides a method of determining the change of resistance with temperature of wires of the manganin and constantan types and for computing the constants of the resistance-temperature equation. It is suitable for wires to be used in precision electrical apparatus.

Tentative Standards Continued as Tentative.—The committee recommends that the following tentative standards be continued as tentative for another year without revision:

Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (B 71 – 29 T);

Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 29 T);

Tentative Method of Test for Thermoelectric Power (B 77 – 30 T).

The recommendations in this report have been submitted to letter ballot of the committee, which consists of 30 members, with the following results:

ITEMS	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARDS			
Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements	17	0	3
Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, Balance Iron, for Electrical Heating Elements	17	0	3
Method of Test for Determining the Temperature-Resistance-Constants of Resistance Alloys	16	0	4

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Life Tests (J. W. Harsch, chairman).—Progress has been made in the comparative tests to show the relation between the life of electrical heating wires as indicated by the Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (B 76 – 29 T), and the life of the same wire under service conditions in a radiant electric toaster unit. Two lots of wire, of short and long life, respectively, as indicated by the accelerated life test are being used. Each lot has been tested by the accelerated life test. The service tests are being made on line voltage and also with close voltage control, using a current cycle of 2 minutes on and 2 minutes off as in the life test. Six laboratories are cooperating in the tests.

The question of preparing an accelerated life test to allow larger sizes of wire to be tested is being studied.

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[1] See p. 732.—ED.

Subcommittee II on Electrical Tests (H. L. Curtis, chairman).—During the year the work of Subcommittee II has been confined to the preparation of a method of test for determining the resistance-temperature constants of resistance alloys of the kind used in precision electrical apparatus. A round robin series of tests has shown that by proper preliminary treatment definite constants can be obtained. Based on this experience the proposed Tentative Method appended hereto,[1] was prepared and it is being submitted for publication as tentative. An appendix to this method will be prepared next year describing a suitable procedure for making the resistance measurements with the required accuracy.

Subcommittee IV on Mechanical Tests (Mr. P. H. Brace, chairman).—Further work has been done with the bend test for determining the elastic properties of alloys at temperatures up to 1000° C. The permanent change in curvature produced by heating metal strips to various temperatures while constrained to known curvatures has been determined.

It has been shown that the proportional limit as determined by the tension test at room temperature corresponds to the sharp bend in the permanent bending curve at the same temperature.

This work has been carried on under the direction of Mr. Howard Scott, and is described in a paper which will be presented at this annual meeting of the Society.[2]

Subcommittee V on Wrought and Cast Alloys For High-Temperature Use (C. L. Clark, chairman).—This subcommittee is developing a standard tension test specimen for cast alloys together with the mold construction and foundry practice necessary to insure a sound specimen.

A method of test for thermal coefficient of linear expansion has been prepared and is being checked by several laboratories.

A study is being made of warpage and to determine the relation to it of thermal expansion and heat conductivity.

The subcommittee is also preparing a method of test for thermal conductivity.

Subcommittee VI on Specifications (J. W. Harsch, chairman).—This subcommittee has prepared specifications for two grades of drawn or rolled alloys for electrical heating elements; namely, Proposed Tentative Specifications for Drawn or Rolled 80 per cent Nickel, 20 per cent Chromium Alloy for Electrical Heating Elements, and Proposed Tentative Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, Balance Iron, for Electrical Heating Elements. The specifications correspond to the two grades of alloys in general use for electrical heating elements. These specifications which are appended hereto[1] are being recommended for publication as tentative.

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[1] See p. 732.—ED.

[2] Howard Scott, "High-Temperature Characteristics of Metals Revealed by Bending," see *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 129 (1931).

This report has been submitted to letter ballot of the committee, which consists of 30 members; 20 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

DEAN HARVEY,
Chairman.

F. E. BASH,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements; Specifications for Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, Balance Iron, for Electrical Heating Elements; and Method of Test for Determining the Temperature-Resistance-Constants of Resistance Alloys were accepted for publication as tentative and appear on pages 708, 712 and 732, respectively.

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[1] See pp. 708 to 715.—ED.

REPORT OF COMMITTEE B-5

ON

COPPER AND COPPER ALLOYS, CAST AND WROUGHT

The last meeting of the committee was held at Atlantic City, on June 25, 1930. Various changes in membership have occurred during the past year and the total membership is now 54, classified as 24 producers, 20 consumers, and 10 general interests.

In order to get early action on a revision of the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 30 T), which was not completed in time for final action at the annual meeting of the Society last year, the committee has taken advantage of the Society's new procedure permitting proposed tentative standards and revisions of tentative standards to be reviewed and accepted for publication as tentative by Committee E-10 on Standards between annual meetings. The revised tentative specifications were considered by Committee E-10 and accepted for publication as tentative at a meeting held on August 12, 1930.[1] At this meeting Committee B-5 was represented by Mr. G. H. Clamer.

The committee recommends that the schedule of tolerances on length proposed last year[2] as a tentative revision in the following three standard specifications be continued as tentative for another year: Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 – 29), for Seamless 70 – 30 Brass Condenser Tubes and Ferrule Stock (B 55 – 25), and for Seamless Muntz Metal Condenser Tubes and Ferrule Stock (B 56 – 25).

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Wrought Metals and Alloys (W. R. Webster, chairman).—This subcommittee has recently proposed a number of changes in three standards and one tentative standard under its jurisdiction. These changes are expected to come up for consideration at a meeting of the committee to be held during the annual meeting and include (1) a minor revision in the weight tolerances in the Standard Specifications for Copper Pipe, Standard Sizes (B 42 – 24) and for Brass Pipe, Standard Sizes (B 43 – 24); (2) the inclusion of an expansion test in the Tentative Specifications for Seamless Copper Tubing, Bright Annealed (B 68 – 30 T); and (3) an extensive revision in the Standard Specifications for Sheet High Brass (B 36 – 27).

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[1] In submitting these specifications to Committee E-10, the committee reported the results of the letter ballot vote as follows: 40 members returned their ballot of whom 37 voted affirmatively, none negatively and 3 refrained from voting.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1272 (1930).

The important changes in the specifications for sheet high brass include recognition of two grades, the standardizing on the tension test as a basis for acceptance or rejection on rolled tempers, the standardizing on grain size as a basis for acceptance or rejection for annealed tempers, the inclusion of explanatory data on Rockwell hardness test for both rolled and annealed tempers, and the recognition of five standard annealed tempers in place of three tempers. All these revisions result from a very large amount of work in a number of different laboratories, and it is felt that the specifications will be much more valuable and more widely used as a result of such revision.

The subcommittee had prepared new proposed Specifications for Copper Water Tube, which it had hoped would receive favorable action at the meeting of Committee B-5 during the annual meeting. However, important differences of opinion as to certain items made it necessary to refer the specifications back to Subcommittee I for further consideration. It is expected that during the coming year these specifications will be brought to a satisfactory state for presentation.

Subcommittee II on Cast Metals and Alloys (N. K. B. Patch, chairman).—In view of the systematic study of sand casting alloys now being undertaken by this subcommittee, as mentioned in the 1930 report,[1] which has already resulted in the new Tentative Specifications for Copper-Base Alloys in Ingot Form (B 30 – 30 T) referred to above, it has not been possible thus far to effect a properly matured reconsideration of all specifications for ingot metal and sand castings now in effect.[2] As to the status of the Tentative Specifications for Sand Casting of the Alloy: Copper 80 per cent; Tin 10 per cent; Lead 10 per cent (B 74 – 28 T), and the tentative revision of the Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 21), which have been standing for three years without action, it may be emphasized that all specifications, both tentative and standard for sand castings in the bronzes and brasses which have been published by the Society, are now being carefully reconsidered in the subcommittee with a view to bringing them into thoroughly acceptable form.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 407 (1930).

[2] See Editorial Note, p. 260.—Ed.

This report has been submitted to letter ballot of the committee, which consists of 54 members; 43 members returned their ballots, of whom 37 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

C. H. MATHEWSON,
Chairman.

D. K. CRAMPTON,
Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting, the committee approved a complete revision of the Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings. The revised specifications were accepted for publication as tentative on August 6 by Committee E-10 on Standards. The specifications in their revised form appear on page 703.

REPORT OF COMMITTEE B-6
ON
DIE-CAST METALS AND ALLOYS

Committee B-6 was organized at a meeting held at Atlantic City on June 24, 1930, to take over the work formerly handled by Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys. Officers were elected and the membership was selected in accordance with the requirements of the Society as to the various interests represented. The following subcommittees were appointed to sponsor the different activities of the committee:

Subcommittee I on Aluminum Base Die-Casting Alloys (E. E. Thum, chairman);

Subcommittee II on Zinc-Base Die-Casting Alloys (W. H. Graves, chairman);

Subcommittee III on Tin and Lead-Base Die-Casting Alloys (F. J. Tobias, chairman);

Subcommittee IV on Physical Tests of Die Castings (R. L. Templin, chairman);

Subcommittee V on Exposure and Corrosion Tests (W. M. Peirce, chairman);

Subcommittee VI on Finishing Properties of Die Casting (J. C. Fox, chairman).

Recommendations Affecting Tentative Standards

Proposed Tentative Standards.—The committee submits for publication as tentative, the following two new specifications as appended hereto:[1]

Proposed Tentative Specifications for Aluminum-Base Alloy Die Castings, recommended by Subcommittee I;

Proposed Tentative Specifications for Zinc-Base Alloy Die Castings, recommended by Subcommittee II.

The above recommendations have been submitted to letter ballot of the committee, which consists of 60 members; 34 members returned their ballots. The analysis of the vote of the committee is given in the following table:

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[1] See pp. 716 to 721.—Ed.

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Specifications for Aluminum-Base Alloy Die Castings	27	1	6
Specifications for Zinc-Base Alloy Die Castings	28	0	6

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Aluminum-Base Die-Casting Alloys (E. E. Thum, chairman).—This subcommittee has had three meetings during the year. At the first meeting, held at Atlantic City immediately after its organization, two specifications were drafted: Tentative Specifications for Aluminum-Base Die Castings of Good Commercial Grade, and Tentative Specifications for Aluminum-Base Die Castings of High Grade. In the first it was intended to cover requirements for finished parts where shape and form are the principal desired characteristics, and in the second specifications mentioned, to cover requirements for finished parts where permanence and maximum physical properties are also desired.

These drafts were circulated and a second meeting was held in Chicago in September, 1930, to consider the questions which had arisen. After discussion it was unanimously agreed to drop temporarily the subject of the so-called "high-grade" alloys as covered by the second specification mentioned above, holding this matter for reconsideration when tests now under way more clearly indicate the true effect of metals unintentionally present in the analysis. The other specifications were considered in detail, and a revised draft prepared for distribution to the entire committee for comment. It was voted to restrict the number of alloys in the specifications to seven—those in common use today—thus eliminating five alloys studied by the Society.

Final action on this second draft was taken at a meeting of the subcommittee in New York held in February, 1931. The proposed Tentative Specifications for Aluminum-Base Alloy Die Castings, as approved, are appended hereto[1] and recommended for publication as tentative.

A paper by Mr. D. L. Colwell on "Effect of Composition on Aluminum-Base Die-Casting Alloys," a subject studied by Committee B-6, appears as Appendix I to this report.

Subcommittee II on Zinc-Base Die-Casting Alloys (W. H. Graves, chairman).—This subcommittee held two meetings during the year with good attendance. At these meetings the subcommittee members discussed the data previously reported by Subcommittee XV of Committee B-2 in its annual reports for the past several years,[1] and from these data and other data subsequently obtained reached the following conclusions:

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[1] See p. 716.—ED.

1. That the purest of zinc is necessary to produce stable zinc-base die castings and as a result requested specifications for zinc spelter with total impurities not over 0.02 per cent.
2. That only one zinc-base alloy is necessary to meet all service, production and cost requirements.
3. That the round tension test specimens are the most satisfactory type to use.
4. That the 10-day, 95° C. water vapor aging test is the most suitable test for determining stability of zinc-base die castings.

The results of reaching such definite conclusions was the formation of proposed Tentative Specifications for Zinc-Base Alloy Die Castings which are appended hereto[2] and recommended for publication as tentative.

The new work before the subcommittee at present is the consideration of the development of specifications for other alloys.

Subcommittee III on Tin and Lead-Base Die-Casting Alloys (F. J. Tobias, chairman).—This subcommittee is working on a test program covering representative lead-base and tin-base alloys and has been assured of the cooperation of a number of producers and of testing laboratories.

A preliminary list of alloys has been suggested as representative of the various types of alloys in commercial production. This list is being considered by the various members of the subcommittee and a choice of the alloys to be listed is to be made at the time of the annual meeting.

A paper by Mr. F. J. Tobias entitled "Lead-Base and Tin-Base Alloys for Die Castings" which appears as Appendix II to this report presents the status of this class of die castings in the industry.

Subcommittee V on Exposure and Corrosion Tests (W. M. Peirce, chairman).—This subcommittee has sponsored the testing of the aluminum-base and zinc-base alloy test specimens returned after one year from the various exposure locations. The testing is largely completed as is shown in the following tabulation:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vols. 29 and 30, Part I, pp. 192 and 318 respectively (1929 and 1930).

[2] See p. 719.—ED.

INDOOR TESTS

LOCATION	TESTING LABORATORY	STATUS
Massachusetts Institute of Technology, Cambridge, Mass.	American Brass Co.	Reported
Hanover, New Mexico	Western Electric Co.	Reported
New Kensington, Pa.	Aluminum Co. of America	Not reported
Coco Solo, Panama Canal Zone	U. S. Navy	Not reported

OUTDOOR TESTS

LOCATION	TESTING LABORATORY	STATUS
State College, Pa.	No one-year tests	
New York City	New Jersey Zinc Co. Packard Motor Car Co.	Reported
Sandy Hook, N. J.	Wright Aeronautical Corp.	Tension tests completed
Key West, Fla.	Wright Field	Reported
Altoona, Pa.	The Hoover Co.	Reported
Rochester, N. Y.	General Motors Corp.	Reported

The data are being summarized by the committee so as to permit comparison of the various alloys under the different exposure conditions.

The interest in the work of the committee has increased with the accumulation of data on the properties of die castings as is shown by the increase in membership and by the cooperation of the various members in the various projects which are in progress. The technical literature contains increasing numbers of references to the results which have been obtained in the investigation sponsored by the committee.

This report has been submitted to letter ballot of the committee which consists of 60 members; 34 members returned their ballots, of whom 33 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. A. ANDERSON,
Chairman.

P. V. FARAGHER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Aluminum-Base Alloy Die Castings and for Zinc-Base Alloy Die Castings were accepted for publication as tentative and appear on pages 716 and 719, respectively.

DISCUSSION

MR. G. C. RIEGEL.[1]—I am much interested in the conclusion presented by the committee that only one zinc-base alloy is necessary to meet all service and production requirements. Having sponsored the use of die castings in our plant, we have had much difficulty and much stoppage in production due to having had die castings come in of the zinc-base type containing aluminum in excess of 0.5 per cent, which gave great difficulty in soldering with 50-50 solder. These castings were replacing sand-cast brass fittings and necessarily were subjected to soldering in process. When we encountered that difficulty we immediately began to delimit the percentage of aluminum so that these castings could either be tinned with pure tin or soldered with 50-50 solder.

We found that there were very few of the die castings carrying a high percentage of tin that would stand the accelerated aging test, so we confined our supply to only two sources from which we were able to obtain satisfactory castings.

MR. H. A. ANDERSON[2] (*Chairman, Committee B-6*).—I quite agree with the speaker that the statement regarding alloy No. XXI being the one universally applicable zinc-base die-casting alloy is probably too inclusive in the strict sense. The intent of the statement was that for high-grade stable zinc-base die castings, only one of the nine commercial alloys which Committee B-6 had tested was considered to be suitable for inclusion in the specifications. The difficulties due to tin contamination of a zinc-aluminum-copper alloy are, of course, well known.[3] Committee B-6 has consequently very carefully delimited the amount of tin to a maximum of 0.005 per cent in the specifications as presented. The zinc which is used for these die castings is what is known as 99.99-per-cent zinc and several commercial brands average close to that purity. Such slab zinc has only recently become available on the market in commercial quantities.

The necessity for extremely accurate chemical analytical methods to insure the desired composition of zinc-base die castings is something that has caused us considerable worry. The determination of small amounts of lead, particularly, is a difficult problem and this and other impurities are advantageously determined by spectroscopic analysis. Mr. Graves, the chairman of Subcommittee II of Committee B-6, says that in the purchase of zinc-base die castings by the Packard Motor Car Co. he is using the 95° C. steam or water vapor test as a basis of acceptance, in view of the difficulty of chemical analysis.

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[1] Chief Metallurgist, Caterpillar Tractor Co., Peoria, Ill.

[2] Metallurgical Development Engineer, Western Electric Co., Chicago, Ill.

[3] H. A. Anderson, "Zinc Alloys for High- and Low-Temperature Service," Symposium on Effect of Temperature on the Properties of Metals, published jointly by the American Society for Testing Materials and the American Society of Mechanical Engineers (1931).

In the absence of Mr. Graves, I should like to ask Mr. Peirce to comment on the question that the speaker has raised relative to zinc-base alloys suitable for soldering.

MR. W. M. PEIRCE.[1]—I should like to add to what Mr. Anderson has said, that it is perfectly true that the alloy which has been specified is difficult, though not impossible to solder. I think that the committee recognized that fact, but I believe that most of the members felt, as I feel, that where one of the high-tin, low-aluminum alloys is used in order to gain the advantage of easy soldering, the other requirements have got to be waived to the extent that it does not make much difference what is put in the alloy. The committee felt that it is not worth while writing a specification for such an alloy.

Now, to go entirely outside the alloys which were tested by the committee, I might say that there has been an alloy developed since the initiation of the committee program which has the desirable physical properties of the specified alloy and which does solder very much more easily.

THE CHAIRMAN (*Mr. F. O. Clements*[2]).—I should like to inquire, relative to the zinc-base alloy with the high aluminum content, whether it stands the aging test with the water vapor at 95° C. for ten days?

MR. ANDERSON.—I presume the Chairman refers to the requirement in the tentative specifications under "Aging":

> 8. (*a*) The alloy shall conform to the following requirements as to physical properties after being exposed to water vapor at 95° C. for ten days:

	AVERAGE OF 5 SPECIMENS
Tensile strength, minimum, lb. per sq. in.	30 000
Elongation in 2 in., minimum, per cent	0.5
Impact Charpy, minimum, ft-lb	0.75
Expansion per inch, maximum, in.	0.0025

Our recommended "Alloy XXI" will satisfy the strength and ductility requirements and will also satisfy the expansion requirement. Committee B-6 gave very serious consideration to the possibility of the use of these atmospheric exposure tests as practical requirements that could be enforced on purchased die-cast parts, and they were in unanimous agreement on the practicability of the test as recommended.

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[1] Chief, Metal Research Division, New Jersey Zinc Co., Palmerton, Pa.

[2] Technical Director, Research Laboratories, General Motors Corp., Detroit, Mich.

There was some discussion within the committee as to the relative desirability of using a short-time test at 95° C. in water vapor as compared to a longer test at 70° C. in water vapor. The lower temperature test will come closer to simulating atmospheric conditions in humid climates, but the shorter, more severe test is more practicable for an acceptance test by the purchaser and gives parallel results according to the committee's data.

MR. CLEMENTS.—The reason I raised the question is because of the fact that about twenty-five years ago, when I was associated with the National Cash Register Co., we utilized zinc-base die-cast alloys and received a great many complaints from tropical countries having to do with growth and distortion. We could not believe it; we made up samples and bars machining them very accurately and put them outdoors, exposed to all kinds of weather conditions common to this climate. They were carefully calipered and showed no signs of any growth, until one day we happened to get high temperature and humidity together. Then we did find that they grew in a very marvelous way. About twenty-five adding wheels were assembled on a shaft of a certain length, with a lot of clearance between the individual wheels. After months of exposure in various tropical countries, they just tied up tight so that they could hardly be moved with a crowbar. That alloy had 1 per cent aluminum in its make-up. At the time, we did not know the cause of the trouble and for a long time we could hardly believe such serious effects could be produced in tropical climates and that these alloys deteriorated so greatly as to make them practically useless.

MR. ANDERSON.—I think that this is an example where modern metallurgical research has done considerable for the die-casting industry. We know now what is responsible. I do not have to go back twenty-five years for an example such as the Chairman cites. I have to date lost two handles on my automobile which were die-cast from inferior zinc-base alloys and failed due to intercrystalline corrosion. I think that most of us have had experience with what happens to zinc-base die castings when they get in a hot humid atmosphere. If my next car has a die-cast radiator cap that can be opened and closed without having to use a Stillson wrench, I will consider that the improvements in zinc-base alloys have been profitably applied by the automobile manufacturers.

APPENDIX I

EFFECT OF COMPOSITION ON ALUMINUM-BASE DIE-CASTING ALLOYS

By D. L. Colwell[1]

Introduction

When Committee B-6 on Die-Cast Metals and Alloys (then Subcommittee XV of Committee B-2 on Non-Ferrous Metals and Alloys) was organized, it outlined a program which involved the determination of the various physical properties of the commonly used aluminum-base die-casting alloys. With these properties in mind, specifications were to be written defining and limiting such of these alloys as were found to possess desirable characteristics.

The committee thereupon selected twelve aluminum-base die-casting alloys **(1)**;[2] and five manufacturers of die castings submitted die-cast test bars of these alloys to the committee for purposes of test **(2)**. The compositions of the alloys were defined only nominally, although certain impurities (that is, iron, manganese and magnesium) were definitely limited. These die-cast test bars were then submitted to eight laboratories for physical testing and to several others for chemical analysis **(2)**. The results of this testing form a voluminous record; and they are now being circulated by the committee.

There is such an enormous volume of these data that careful interpretation of them is necessary in order to prevent the drawing of false conclusions. Attempts have been made to analyze them by statistical analysis **(3)**; but it was felt that this method makes no allowance for known variables occurring in the manufacturing process, and consequently it was not carried to a conclusion. In the meantime, the facts and figures circulated by the committee have had no interpretation, and general conclusions have been drawn by inference which have not been correct in all cases. It is the purpose of this paper to point out how a study of the physical tests of the aluminum-base alloys, with consideration of their chemical compositions as determined by analysis, changes the apparent relative values of these alloys. This study represents a preliminary review of the data thus far presented to the committee. There are other factors that enter into the production of successful die castings, such as change in dimensions with aging, corrosion, machineability, and plating and finishing properties which have not been considered.

Test Bar Compositions

The nominal compositions of the aluminum-base alloys agreed upon attempted to control the inpurities present, but put no tolerances on the alloying elements **(1)**. Iron was to be held between 1.5 and 2.0 per cent, manganese and magnesium were to be 0.05 per cent or less, and no mention was made of zinc. When analytical results of the test bars submitted were available, however, wide variations in both alloying elements and impurities were found **(4)**. Surprised at this lack of alloy control by several of the die-casting producers, the committee voted to set aside the physical data from test bars which showed marked deviation from the specified limits (5). Inasmuch as no official analysis of the data has been made, however, results from these off-grade test bars have not been set aside; and conclusions on the physical properties of aluminum alloys are still influenced by the excessive impurities found in certain of the test bars submitted.

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[1] Metallurgist, Stewart Die Casting Corp., Chicago, Ill.

[2] The boldface numbers in parentheses refer to the reports and papers given in the list of references appearing on page 277.

Subcommittee I of Committee B-6 has prepared proposed specifications for aluminum-base alloy die castings which are being recommended for publication as tentative.[1] During its deliberations it set up tentative composition limits for all but one of the aluminum-base alloys tested by the committee, and subsequently omitted several of the alloys in the final draft of the proposed tentative specifications. Inasmuch as the original nominal compositions (1) limited only three elements, the first tentative composition limits as set up by Subcommittee I have been used in this paper to determine whether or not the test bars were up to the compositions agreed upon. These composition limits are shown in Table I, with similar limits shown for alloy No. X not listed by Subcommittee I (6). It is felt that the limits set up in Table I are entirely fair, as they are broad enough to be applied to ordinary commercial die castings, and yet so narrow that every cooperating producer but one submitted test bars outside the limits in several cases.

TABLE I.—COMPOSITION LIMITS FOR ALUMINUM DIE-CASTING ALLOYS (6).

Alloy	Copper, per cent	Silicon, per cent	Nickel, per cent	Iron, maximum, per cent	Zinc, maximum, per cent	Manganese, maximum, per cent	Magnesium, maximum, per cent	Tin, maximum, per cent	Total Other Impurities, maximum per cent	Aluminum, per cent
No. I.....	3.5 to 5	2.0 max.	1.0 max.	2.5	1.0	0.3	0.1	0.1	0.2	90.5 minimum
No. II....	9 to 11	2.0 max.	1.0 max.	2.5	1.0	0.3	0.1	0.1	0.2	balance
No. III...	12.5 to 15	2.0 max.	1.0 max.	2.5	1.0	0.3	0.1	0.1	0.2	balance
No. IV...	0.6 max.	4.5 to 6.0	0.5 max.	2.0	0.75	0.3	0.1	0.1	0.2	balance
No. V....	0.6 max.	11 to 13	0.5 max.	2.0	0.75	0.5	0.1	0.1	0.2	balance
No. VI...	1.5 to 2.5	2.5 to 3.5	0.5 max.	2.5	0.75	0.3	0.1	0.1	0.2	balance
No. VII..	3.5 to 4.5	4.5 to 5.5	0.5 max.	2.25	0.75	0.3	0.1	0.1	0.2	balance
No. VIII.	1 to 2	0.75 to 2	1.75 to 2.5	2.5	0.75	0.3	0.1	0.1	0.2	balance
No. IX...	3.5 to 4.5	1.0 to 2.5	3.5 to 4.5	2.5	0.75	0.3	0.1	0.1	0.2	balance
No. X[a]...	0.6 max.	1.5 to 2.5	4.5 to 5.5	2.0	0.75	0.3	0.1	0.1	0.2	balance
No. XI...	1.5 to 2.5	7 to 8.5	0.5 max.	2.25	0.75	0.3	0.1	0.1	0.2	balance
No. XII..	7 to 9	1 to 2	1.0 max.	2.5	1.0	0.3	0.1	0.1	0.2	balance

[a] Limits on Alloy No. X have been added by the author.

The chemical analyses of the aluminum-base alloys as made by cooperating laboratories are shown in Table II (4). Neglecting calcium, which was not found in any case, there were nine elements determined in each of twelve alloys from each of five producers, a total of 540 different determinations listed in Table II. Fifty-six of these determinations showed the elements outside of the limits noted in Table I. These 56 off-grade elements occurred in thirty-one samples. Each one of five producers submitted twelve samples, a total of 60 samples, so that 31 out of 60 or over half of the aluminum alloy samples submitted were not exactly what they were supposed to be. It also follows that half of the aluminum alloy data circulated by the committee cannot be used as intended, because they represent properties of alloys that are too far away from the nominal compositions agreed upon.

A study of the elements outside the limits in Table II is made in Table III. Producer W had only one alloy in twelve within the limits of Table I; producer

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[1] See p. 716.

TABLE II.—RESULTS OF CHEMICAL ANALYSES OF ALUMINUM-BASE DIE-CASTING ALLOYS (4).

Alloy	Producer	Number of Analyses	Chemical Composition, Average of All Laboratory Analyses										
			Copper, per cent	Silicon, per cent	Nickel, per cent	Iron, per cent	Manganese, per cent	Magnesium, per cent	Zinc, per cent	Calcium, per cent	Tin, per cent	Lead, per cent	Aluminum, per cent
No. I.....	nominal	..	4	....	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (94)
	C.......	3	4.37	0.43	Nil	1.48	0.01	0.03	0.05	Nil	Nil	....	93.63
	D.......	2	3.51	0.63	0.17	1.50	0.03	0.03	0.18	Nil	Nil	....	93.95
	G.......	3	3.97	0.32	0.03	2.77	0.02	0.01	Nil	Nil	0.08	....	92,80
	S.......	3	4.23	0.59	0.45	1.90	0.02	0.04	0.03	Nil	Nil	....	92.74
	W	2	3.80	0.31	Nil	2.35	0.03	Nil	0.08	Nil	Nil	....	93.43
No. II....	nominal	..	10	....	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (88)
	C.......	3	7.13	0.38	Nil	1.96	0.01	0.04	0.16	Nil	Nil	....	90.32
	D.......	2	8.97	0.34	0.05	1.44	0.03	0.13	0.09	Nil	Nil	....	88.95
	G.......	3	9.36	0.31	Nil	1.71	0.02	Nil	Nil	Nil	Nil	....	88.60
	S.......	3	10.47	0.44	Nil	1.44	0.01	0.01	0.05	Nil	Nil	....	87.58
	W.......	2	8.93	0.44	Nil	3.07	0.03	Nil	0.20	Nil	Nil	....	87.33
No. III...	nominal	..	14	....	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (84)
	C.......	3	11.99	0.43	0.14	1.76	0.02	0.03	0.09	Nil	Nil	....	85.54
	D.......	2	13.14	0.32	0.12	1.67	0.08	0.03	0.09	Nil	Nil	....	84.55
	G.......	3	14.29	0.27	Nil	1.72	0.02	0.01	0.03	Nil	Nil	....	83.66
	S.......	3	13.20	0.53	Nil	1.57	0.01	0.01	0.08	Nil	Nil	....	84.60
	W.......	2	13.02	0.37	Nil	2.74	0.03	0.02	0.11	Nil	Nil	....	83.71
No. IV...	nominal	..	....	5	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (93)
	C.......	3	0.58	4.16	0.01	1.85	0.01	0.07	0.02	Nil	Nil	....	93.30
	D.......	2	0.34	5.07	Nil	1.48	0.07	0.06	0.44	Nil	Nil	....	92.54
	G.......	3	0.68	5.27	Nil	1.29	0.02	0.01	Nil	Nil	Nil	....	92.73
	S.......	3	0.24	5.11	0.22	1.89	0.04	0.01	0.11	Nil	Nil	....	92.38
	W.......	2	0.61	4.41	Nil	2.53	0.03	0.02	5.90	Nil	Nil	....	86.50
No. V....	nominal	..	....	13	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (85)
	C.......	3	0.64	13.00	0.08	1.59	0.19	0.09	0.22	Nil	Nil	....	84.20
	D.......	2	0.98	12.96	0.03	1.52	0.09	0.12	0.90	Nil	Nil	....	83.40
	G.......	3	0.15	12.42	Nil	1.89	0.03	0.01	0.03	Nil	0.06	0.21	85.20
	S.......	3	0.05	12.97	0.02	1.35	0.02	0.03	0.06	Nil	Nil	....	85.50
	W.......	2	0.20	10.72	Nil	4.34	0.06	0.04	0.60	Nil	Nil	....	84.04
No. VI ..	nominal	..	2	3	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (93)
	C.......	3	1.91	2.96	0.35	1.30	0.66	0.05	0.42	Nil	Nil	....	92.35
	D.......	2	1.98	3.19	Nil	1.53	0.04	0.07	0.32	Nil	Nil	....	92.87
	G.......	3	2.06	3.23	Nil	1.98	0.03	0.01	0.01	Nil	Nil	Nil	92.68
	S.......	3	2.18	3.27	Nil	1.86	0.02	0.02	0.04	Nil	Nil	....	92.61
	W.......	2	2.16	5.02	Nil	3.38	0.06	0.01	0.16	Nil	Nil	....	89.21
No. VII..	nominal	..	4	5	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (89)
	C.......	3	3.53	5.11	0.09	1.45	0.20	0.01	0.43	Nil	Nil	....	89.18
	D.......	2	3.86	5.18	0.04	1.51	0.05	0.04	0.38	Nil	Nil	....	88.94
	G.......	3	3.92	4.83	Nil	1.56	0.16	Nil	0.08	Nil	0.76	0.48	88.11
	S.......	3	3.78	5.08	0.14	1.86	0.02	0.01	0.12	Nil	Nil	....	89.21
	W.......	2	3.53	5.70	Nil	3.07	0.05	Nil	0.22	Nil	Nil	....	87.43
No. VIII.	nominal	..	1.5	0.75	2.25	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (94)
	C.......	3	1.56	0.46	1.50	1.67	0.02	0.01	0.03	Nil	Nil	....	94.75
	D.......	2	1.90	0.85	2.22	1.70	0.05	0.03	0.10	Nil	Nil	....	93.15
	G.......	3	1.63	1.43	1.84	1.58	0.10	0.01	Nil	Nil	Nil	Nil	93.41
	S.......	3	1.85	0.95	2.38	1.63	0.06	0.03	0.05	Nil	Nil	....	93.05
	W.......	2	0.45	2.06	0.90	3.52	0.08	0.01	0.07	Nil	Nil	....	92.91
No. IX...	nominal	..	4	1.5	4	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (89)
	C.......	3	4.12	2.30	4.31	1.19	0.63	0.01	0.28	Nil	Nil	....	87.16
	D.......	2	3.86	1.64	3.78	1.15	0.04	0.04	0.23	Nil	Nil	....	89.26
	G.......	3	4.07	1.46	3.68	1.74	0.03	0.01	Nil	Nil	Nil	Nil	89.01
	S.......	3	4.15	1.55	3.83	1.68	0.06	0.02	0.12	Nil	Nil	....	88.59
	W.......	2	3.28	3.58	1.06	4.97	0.08	0.01	0.18	Nil	Nil	....	86.84
No. X....	nominal	..	....	2	5	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (91)
	C.......	3	0.44	2.06	4.39	1.05	0.73	0.09	0.09	Nil	Nil	....	91.15
	D.......	2	0.20	2.30	4.54	1.00	0.05	0.04	0.27	Nil	Nil	....	91.60
	G.......	3	0.52	1.93	4.61	1.47	0.04	0.01	0.08	Nil	Nil	Nil	91.34
	S.......	3	0.32	2.03	4.89	1.63	0.07	0.04	0.13	Nil	Nil	....	90.89
	W.......	2	0.76	1.78	4.29	1.88	0.06	trace	0.24	Nil	Nil	....	90.99
No. XI...	nominal	..	2	8	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (88)
	C.......	3	2.00	7.48	0.67	0.99	0.70	0.02	0.10	Nil	Nil	....	88.04
	D.......	2	0.33	7.95	Nil	1.40	0.04	0.03	0.51	Nil	Nil	....	89.74
	G	3	2.09	7.65	Nil	0.90	0.03	0.03	0.06	Nil	0.16	Nil	89.08
	S.......	3	2.07	7.30	0.21	1.92	0.02	0.04	0.08	Nil	Nil	....	88.36
	W.......	2	1.46	6.86	0.37	2.91	0.04	0.01	0.36	Nil	Nil	....	87.99
No. XII..	nominal	..	8	1	....	1.5 to 2	0.05^a	0.05^a	....	....	....	....	remainder (89)
	C.......	3	7.62	0.72	0.10	1.74	0.01	0.02	0.04	Nil	Nil	....	89.75
	D.......	2	7.86	1.20	0.04	1.60	0.02	0.18	0.14	Nil	Nil	....	88.96
	G.......	3	7.90	1.17	Nil	1.00	0.02	0.03	0.07	Nil	0.40	Nil	89.41
	S.......	3	7.55	1.48	Nil	1.97	0.01	0.03	0.09	Nil	Nil	....	88.87
	W.......	2	6.83	3.08	0.03	2.57	0.05	0.01	0.12	Nil	Nil	....	87.31

[a] Maximum.

C had only two; producer G had six; producer D eight; and producer S had all twelve within these limits. Satisfactory samples of alloys Nos. V, XI and XII were submitted by only one producer; of alloys Nos. II and IV by two producers; of alloys Nos. III, VI, VII, VIII, IX and X by three producers; and of alloy No. I by four producers. In no one of the twelve alloys did all five producers submit samples whose composition was in accordance with the limits set up in Table I.

The committee's physical tests on die castings included tensile strength, elongation, hardness, impact and specific gravity measurements. Since a measurement of the brittleness or toughness of a die-casting alloy is usually of most importance in evaluatiing that alloy for service in a die casting, and since brittleness or toughness is most easily affected by composition, the effect of these composition errors upon impact strength is of greater interest than the effect upon other physical properties. Although eight laboratories cooperated in the physical testing, impact strength results are available from only four of these. Laboratory B submitted Izod impact data, and laboratories N, U and W submitted Charpy impact data on all samples. These data are given in Table IV (7), and include values for specimens conforming to the desired composition and also specimens not conforming to the desired analysis.

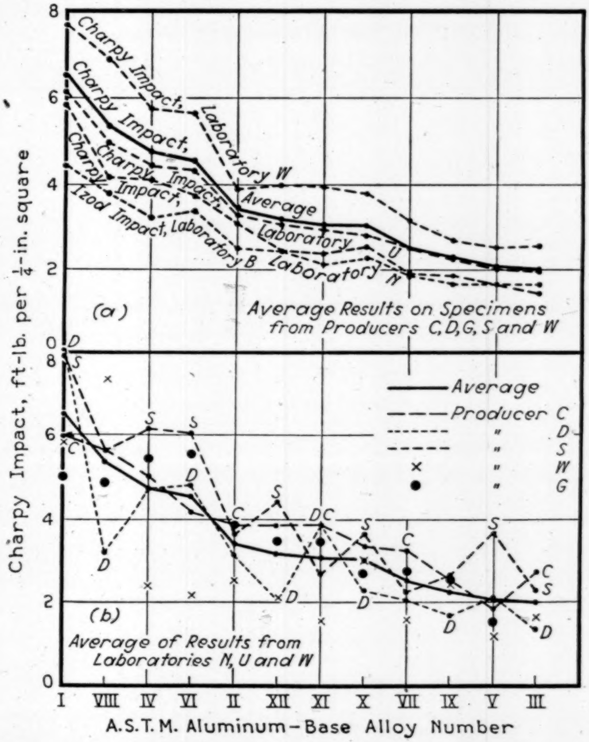

FIG. 1.—Impact Strengths of Aluminum Alloys (All Data Included).

A comparison of laboratories submitting impact results is made in Fig. 1 (*a*) from the data of the "inclusive average" column of Table IV arranged in order of

TABLE III.—NUMBER OF TIMES ELEMENTS WERE OUTSIDE LIMITS.

Producer	Copper	Silicon	Nickel	Iron	Manganese	Magnesium	Zinc	Tin	Lead	Total	Samples Involved
ARRANGED ACCORDING TO PRODUCERS											
C........	3	3	3	0	4	0	0	0	0	13	10
D........	3	0	0	0	0	3	1	0	0	7	4
G........	1	0	0	1	0	0	0	3	2	7	6
S........	0	0	0	0	0	0	0	0	0	0	0
W........	7	8	3	10	0	0	1	0	0	29	11
Total...	14	11	6	11	4	3	2	3	2	56	31
ARRANGED ACCORDING TO ALLOY COMPOSITIONS											
No. I.....	0	0	0	1	0	0	0	0	0	1	1
No. II....	3	0	0	1	0	1	0	0	0	5	3
No. III...	1	0	0	1	0	0	0	0	0	2	2
No. IV...	2	2	0	1	0	0	1	0	0	6	3
No. V....	2	1	0	1	0	1	1	0	1	7	4
No. VI...	0	1	0	1	1	0	0	0	0	3	2
No. VII...	0	1	0	1	0	0	0	1	1	4	2
No. VIII..	1	2	2	1	0	0	0	0	0	6	2
No. IX...	1	1	1	1	1	0	0	0	0	5	2
No. X....	1	0	2	0	1	0	0	0	0	4	2
No. XI...	2	1	1	1	1	0	0	1	0	7	4
No. XII..	1	2	0	1	0	1	0	1	0	6	4
Total...	14	11	6	11	4	3	2	3	2	56	31

TABLE IV.—IMPACT TEST DATA (7) ON ALUMINUM ALLOYS FROM ALL PRODUCERS AND TESTED BY FOUR LABORATORIES.

(Foot-pounds per ½-in square bar)

Alloy	Charpy Impact Results by Laboratories N, U and W							Izod Impact Results by Laboratory B						
	Producer C	Producer D	Producer G	Producer S	Producer W	Inclusive Average	Average Values, Alloys Inside Specified Limits	Producer C	Producer D	Producer G	Producer S	Producer W	Inclusive Average	Average Values, Alloys Inside Specified Limits
No. I....	6.00	8.03	4.97[b]	7.93	5.83	6.55	6.95	3.51	5.5[a]	3.0[b]	5.5[a]	4.75	4.45	4.82
No. II...	3.83[c]	3.13[d]	3.87	3.63	2.53[e]	3.40	3.75	2.60[c]	1.9[d]	2.8	3.1	2.08[e]	2.50	2.95
No. III..	2.77[c]	1.37	2.00	2.30	1.63[b]	2.01	1.89	1.81[c]	1.2	1.8	2.0	1.65[b]	1.69	1.67
No. IV..	5.00[f]	4.70	5.43[c]	6.17	2.40[g]	4.74	5.44	3.47[f]	2.8	3.5[c]	4.1	2.18[g]	3.21	3.45
No. V...	1.83[c]	2.17[h]	1.57[i]	3.63	1.20[j]	2.08	3.63	1.46[c]	1.5[h]	1.4[i]	2.8	1.11[j]	1.65	2.80
No. VI..	4.17[k]	4.80	5.57	6.07	2.13[j]	4.55	5.48	2.82[k]	2.8	3.8	5.5[a]	1.93[j]	3.37	4.03
No. VII..	3.23	2.03	2.80[l]	2.27	1.60[j]	2.52	2.51	2.49	1.5	1.7[l]	2.3	1.20[j]	1.84	2.10
No. VIII.	5.63[m]	3.20	4.87	5.63	7.33[n]	5.33	4.57	3.71[m]	3.0	3.5	4.1	4.60[n]	3.78	3.53
No. IX..	2.57[k]	1.70	2.57	2.67	2.43[n]	2.25	2.31	1.15[k]	1.3	2.0	2.0	1.85[n]	1.66	1.77
No. X...	3.47[o]	2.30	2.73	3.67	3.03[p]	3.04	2.90	2.44[o]	1.7	2.0	2.6	2.74[p]	2.30	2.10
No. XI..	3.87[o]	3.83[c]	3.43[q]	2.70	1.53[r]	3.07	2.70	2.34[o]	2.6[c]	2.5[q]	1.9	1.19[r]	2.11	1.90
No. XII.	3.83[f]	2.03[s]	3.47[q]	4.40	2.10[r]	3.17	4.40	2.63[f]	1.5[s]	2.6[q]	3.5	1.83[r]	2.41	3.50
Average.	3.84	3.27	3.61	4.26	2.81	3.56	3.88	2.58	2.28	2.55	3.28	2.26	2.59	2.89

[a] Result submitted as "over 5" and tabulated as 5.5.

[b] Iron content outside specified limit.

[c] Copper content outside specified limit.

[d] Copper and magnesium contents outside specified limits.

[e] Copper and iron contents outside specified limits.

[f] Silicon content outside specified limit.

[g] Copper, silicon, iron and zinc contents outside specified limits.

[h] Magnesium, copper and zinc contents outside specified limits.

[i] Lead content outside specified limit.

[j] Silicon and iron contents outside specified limits.

[k] Manganese content outside specified limit.

[l] Tin and lead contents outside specified limits.

[m] Silicon and nickel contents outside specified limits.

[n] Copper, silicon, nickel and iron contents outside specified limits.

[o] Nickel and manganese contents outside specified limits.

[p] Copper and nickel contents outside specified limits.

[q] Tin content outside specified limit.

[r] Iron, copper and silicon contents outside specified limits.

[s] Magnesium content outside specified limit.

descending impact strength. The Izod values are uniformly lower than the Charpy, and there is some variation between the three laboratories submitting Charpy data. The average Charpy line, however (without considering composition), gives the relative order of impact strength accurately and is also roughly parallel to the Izod line. Using the Charpy average as a standard, comparison is made with the data from the individual producers in Fig. 1 (*b*).

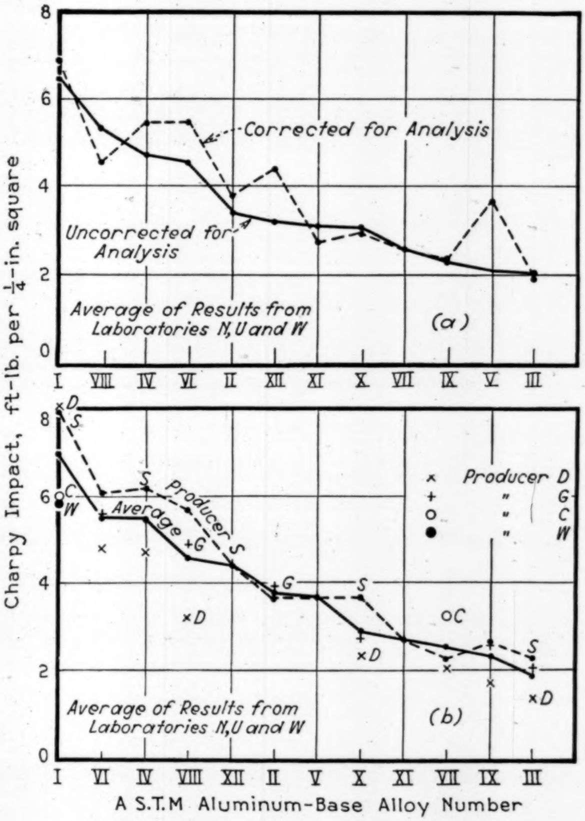

FIG. 2.—Effect of Composition on Charpy Impact Strength.
(*a*) Averages.
(*b*) Using only Data from Specimens Analytically Correct.

The general lack of coordination and the likelihood of drawing false conclusions based on such data are here strikingly shown.

According to the inclusive data plotted in Fig. 1 (*a*), the impact strengths of the alloys arrange them in the following order: Nos. I, VIII, IV, VI, II, XII, XI, X, VII, IX, V, III. The low-copper-silicon-nickel alloy (No. VIII) is in second place, and the high-silicon alloy (No. V) next to the last. The low-copper alloy (No. I) and the high-copper alloy (No. III) are in first and last places, respectively, but they are not being considered for specifications. The No. 12 aluminum (No. XII) alloy is in sixth place, of average impact strength.

Where composition is considered, however, the results are somewhat different. In Table IV the impact values of those alloys conforming to the desired analysis are indicated in boldface type, and the values of those alloys not conforming to the approved compositions are also given with the elements outside the specified limits indicated. The average Charpy strengths of those alloys inside the specified limits from Table IV are plotted in Fig. 2 (*a*), together with the uncorrected average line from Fig. 1 (*a*). This new corrected average line is replotted in Fig. 2 (*b*), rearranging the alloys in order of descending corrected Charpy values. The individual producer values are also shown in Fig. 2 (*b*), and the absence of most of the heterogeneity of Fig. 1 (*b*) is striking. Producer S, the only one to supply all specimens of correct composition, is the only individual complete curve in Fig. 2 (*b*), and it is in reasonable accord with the average.

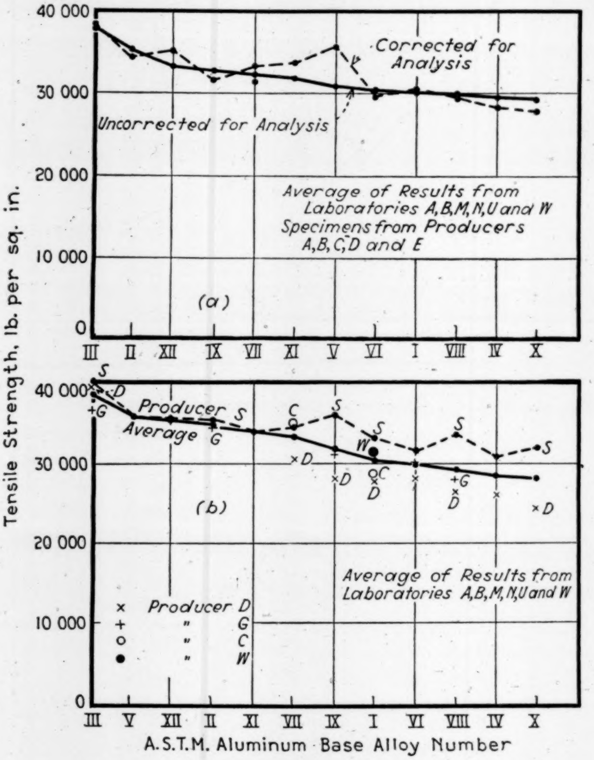

FIG. 3.—Effect of Composition on Tensile Strength.
(*a*) Averages.
(*b*) Using only Data from Specimens Analytically Correct.

Arranging the alloys having proper compositions according to relative corrected impact strengths, they fall in the following order: Nos. I, VI, IV, VIII, XII, II, V, X, XI, VII, IX, III. The low-copper-silicon-nickel alloy (No. VIII) is down to fourth place below the low-silicon alloy (No. IV) and with practically the same impact strength as the No. 12 aluminum (No. XII) alloy which rates fifth. The high-silicon alloy (No. V) has been raised to seventh place; instead of being one of the poorest in the list it is of average impact strength. Other changes are of less importance.

Correction of the impact strength data circulated by the committee for specimens of erratic composition, therefore, proves that the low-copper-silicon-nickel alloy (No. VIII) is not as tough as the uncorrected data indicated, and that the No. 12 aluminum (No. XII) alloy, and the high-silicon alloy (No. V) are not as brittle as the uncorrected data indicated.

TENSILE STRENGTH DATA

The tensile strength relations are similarly affected. Six of the eight cooperating laboratories submitted tensile data on specimens from all producers. The inclusive data from these six are averaged and presented in Table V and Figs. 3 (*a*) and (*b*) (7). In Fig. 3 (*a*), the alloys are arranged in order of descending tensile strength according to the uncorrected averages, and the averages for specimens having proper compositions only are also plotted. In Fig. 3 (*b*), they are rearranged according to the corrected averages and the individual producers' results are also included where the corresponding samples are analytically correct. As in Fig. 2 (*b*), the only individual complete curve is that of Producer S, because all twelve of his alloys were acceptable.

TABLE V.—TENSILE STRENGTH TEST DATA (7); SPECIMENS FROM ALL PRODUCERS TESTED BY LABORATORIES, A, B, M, N, U AND W.

(Pounds per square inch on round test bar only)

Alloy	Producer C	Producer D	Producer G	Producer S	Producer W	Uncorrected Average	**Average, Desired Compositions only**
No. 1	28 593	27 503	29 576[a]	32 939	31 596	30 041	**30 158**
No. II	34 756[a]	34 742[a]	34 282	35 141	36 724[a]	35 129	**34 711**
No. III	37 503[a]	39 424	36 453	40 400	38 831[a]	38 522	**38 759**
No. IV	30 018[a]	25 893	29 812[a]	30 569	29 969[a]	29 252	**28 231**
No. V	33 567[a]	27 435[a]	28 297[a]	35 818	29 055[a]	30 834	**35 818**
No. VI	29 601[a]	27 995	29 906	31 218	32 529[a]	30 250	**29 706**
No. VII	34 977	30 222	30 235[a]	34 175	31 935[a]	32 309	**33 125**
No. VIII	31 311[a]	26 045	27 874	33 295	30 474[a]	29 800	**29 071**
No. IX	31 612[a]	27 843	30 979	35 847	36 842[a]	32 625	**31 556**
No. X	31 984[a]	24 056	27 932	31 609	29 600[a]	29 036	**27 866**
No. XI	35 548[a]	29 453[a]	30 845[a]	33 813	29 805[a]	31 893	**33 813**
No. XII	33 380[a]	33 791[a]	29 874[a]	35 044	35 241[a]	33 466	**35 044**
Average	32 742	29 533	30 505	34 155	32 717	31 930	**32 322**

[a] Specimens did not conform to the desired chemical compositions.

The uncorrected alloy arrangement for tensile strength is as follows: Nos. III, II, XII, IX, VII, XI, V, VI, I, VIII, IV, X. When corrections for compositions have been made the arrangement is: Nos. III, V, XII, II, XI, VII, IX, I, VI, VIII, IV, X. As in the case of the impact strength arrangement, the high-silicon alloy (No. V) is grossly underrated in the uncorrected arrangement, being in seventh place. It is raised to second place when corrected for composition. The No. 12 aluminum (No. XII) alloy is in third place in both arrangements, a strong alloy; and the low-copper-silicon-nickel alloy (No. VIII) is in tenth place in both arrangements, a weak alloy. The high-copper-silicon-nickel alloy (No. IX) drops from fourth to seventh place, although its actual change in tensile strength is not great.

Correction of the tensile strength data circulated by the committee, therefore, proves that the high-silicon alloy (No. V) is much stronger than the uncorrected data indicated. Eliminating the high-copper alloy (No. III), the high-silicon alloy (No. V) is the strongest of all, and the No. 12 aluminum (No. XII) alloy is a very close second.

OTHER PHYSICAL TESTS

In addition to impact and tensile strength, the other physical tests included elongation, hardness and specific gravity. The hardnesses and specific gravities were more affected by porosity than by composition and have not been studied in detail. The elongation values were affected by both composition and porosity, so conclusions drawn from them would not be nearly as convincing as those drawn from the impact data. The two agree, however, in improving the positions of the high-silicon alloy (No. V) and the No. 12 aluminum (No. XII) alloy, and in lowering the positions of the medium-silicon alloy (No. XI) and the lowcopper-silicon-nickel alloy (No. VIII). The elongation data are given in Table VI (7), although the presentation of a detailed analysis is unnecessary.

TABLE VI.—ELONGATION IN 2 IN. ON ROUND TEST BARS (7); SPECIMENS FROM ALL PRODUCERS TESTED BY LABORATORIES A, B, M, N, U, AND W.

ALLOY	ELONGATION UNCORRECTED FOR ANALYSIS, PER CENT	ELONGATION CORRECTED FOR ANALYSIS, PER CENT
No. I	4.13	4.44
No. VIII	4.38	3.69
No. VI	3.20	3.62
No. IV	3.14	2.89
No. XII	1.88	2.30
No. II	2.04	2.14
No. X	2.28	2.08
No. V	1.25	1.98
No. VII	1.77	1.89
No. IX	1.62	1.78
No. XI	1.84	1.22
No. III	1.08	0.96

SUMMARY

Data accumulated by Committee B-6 on twelve aluminum-base die-casting alloys produced by five producers have been studied. It was found that only one producer submitted samples of satisfactory composition in all alloys. The physical tests on samples of unsatisfactory composition have affected the results, so that the alloys have been incorrectly evaluated. By eliminating data from the samples of unsatisfactory composition, new relationships have been uncovered and are presented, and certain of the alloys are shown to have different properties. The data studied include those from impact, tension, and elongation tests made by six cooperating laboratories.

CONCLUSIONS

1. Previous relative ratings of aluminum-base die-casting alloys tested by Committee B-6 involving average strengths are inaccurate because of the effects of abnormal variations in composition.

2. The high-silicon alloy (No. V) has been most inaccurately rated. It is a superior alloy, rating average in impact strength and elongation and high in tensile strength.

3. The No. 12 aluminum (No. XII) alloy is also superior, rating average in impact strength and elongation and high in tensile strength.

4. The ratings of low-silicon alloy (No. IV) and the two copper-silicon alloys (Nos. VI and VII) have not been greatly affected by errors of composition.

5. The low-copper-silicon-nickel alloy (No. VIII) has been overrated. It is of average impact strength, high elongation, and low tensile strength.

6. The high-copper-silicon-nickel alloy (No. IX) is of low impact strength and elongation and average tensile strength.

7. The positions of other alloys have been modified somewhat by corrections for composition errors but they are not being considered for specifications.

REFERENCES

(1) List of Alloys Agreed on for Die-Casting Investigation, with Nominal Compositions Desired, Appendix II, Report of Subcommittee XV of Committee B-2 on Non-Ferrous Metals and Alloys, *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 211 (1928).

(2) Report of Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys, *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 204 (1928).

(3) W. A. Shewhart, "Basis for Analysis of Test Results of Die-Casting Alloy Investigation," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p, 200 (1929).

(4) Results of Chemical Analysis of Aluminum-Base Die-Cast Alloys, Table II, Report of Subcommittee XV of Committee B-2 on Non-Ferrous Metals and Alloys, *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 194 (1929).

(5) Minutes of the meeting of Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys, Am. Soc. Testing Mats., held June 26, 1928 (unpublished).

(6) Proposed Specifications for Aluminum-Base Die-Castings of Good Commercial Grade. Minutes of the meeting of Subcommittee I on Aluminum Base Die-Casting Alloys of Committee B-6 on Die-Cast Metals and Alloys, Am. Soc. Testing Mats., held June 26, 1930 (unpublished).

(7) Data taken from progress reports submitted from time to time to members of Committee B-6.

DISCUSSION

MR. SAM TOUR.[1]—I desire to give a word of caution regarding the interpretation of data as presented in the paper by Mr. Colwell. This interpretation is based entirely on chemical composition apparently on the assumption that composition is the only thing of importance affecting the physical properties of aluminum die castings. I know that Mr. Colwell does not mean it that way. We all know that the physical properties of die castings are very seriously affected by casting temperature, casting pressure, die temperature, size of the gate, size of the vents, etc. These items have not been taken into consideration in this analysis of data, and were they taken into consideration you might have an entirely different picture. The difficulty is that we do not have definite data on these items. It is very probable that, with the same analyses of alloys as shown in this paper, but with different casting temperatures, die temperatures, pressures, etc., the relative standing of the different alloys would be different than as shown in this paper.

MR. D. L. COLWELL[2] (*author's closure by letter*).—Mr. Tour is undoubtedly right in mentioning the effect of casting conditions on physical properties. He is wrong, however, in saying that this analysis of the data does not take casting conditions into consideration.

In the original averages, the effects of casting conditions are neutralized. Each alloy was cast by each of five producers. Each producer cast the alloys in his own die, under his own conditions, so that in comparing alloys, the effects of the various casting conditions of different producers are the same for each alloy. When alloys from certain producers are eliminated because of composition errors, however, these balances are disturbed; and it is theoretically possible that some of the changes in the relative positions of alloys are due to the elimination of poorly cast samples from the averages.

Practically, however, that is not the case. The one producer whose specimens were all satisfactory from the composition standpoint happens to be the same one who apparently maintained superior casting conditions. His average impact strength for all alloys is highest (Table IV) and his average tensile strength for all alloys is highest (Table V). A comparison of his values alone, therefore, should minimize the effect of variations in casting conditions.

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[1] Vice-President, Lucius Pitkin, Inc., New York City.

[2] Metallurgist, Stewart Die Casting Corp., Chicago, Ill.

The relative order curves of this producer are very close to the relative order curves of the corrected averages; in Figs. 2 (*b*) and 3 (*b*) the relative standing of the alloys is about the same in the average curve as in that of Producer S. Before the averages are corrected for composition, however, this is not the case, as is shown in Fig. 1 (*b*).

The conclusions in the paper concerning the relative values of the alloys are believed to be warranted, therefore, not only by the corrected average data; but by the data from one set of specimens where variations in casting conditions were almost negligible.

APPENDIX II

LEAD-BASE AND TIN-BASE ALLOYS FOR DIE CASTINGS

By Fred J. Tobias[1]

The preparation of an article on tin and lead-base alloys is made difficult, in view of the many alloys belonging to this group on the market. The addition of nearly every element has been tried to better the physical properties, and this has resulted in a great number of claims protected by patents.

The largest field for die castings of these alloys is as Babbitt metal for bearings. Practically all of the grades of white bearing metal alloys, known commercially as "Babbit Metal" are used. In many cases, the die castings are produced in the form of the Babbitt metal shells to be later placed in or backed up by brass, bronze, or iron. A large part of the production, however, consists of tin-base Babbitt metals cast directly on a brass or bronze shell.

Their use in bearings is only one of the many fields for tin and lead-base alloys in the form of die castings and they have a wide application for other purposes. In describing these uses a classification of the alloys will be made according to the predominance of their tin and lead content as follows:

1. Tin-base alloys (with antimony and copper),
2. Intermediate group (tin and lead-base alloys with antimony and sometimes copper),
3. Lead-base alloys (with tin and antimony),
4. Lead-antimony alloys (no tin).

The alloys in the above groups will be described as to their use in forms of castings made by pressure die-casting processes. The advantage of the pressure die casting is that, with the least amount of machining the castings are very accurate in size, easily interchangeable, and cheaper in price compared with products made by the slow process of sand casting or permanent mold casting. Another advantage is the fine grain size of the structure which results from the quick cooling of the casting after molten metal has been forced with pressure of about 350 lb. per sq. in. into a steel die, which is often water cooled.

A typical composition usable in die casting is given for each of these groups.

Tin-Base Alloys:

(85 per cent tin, 7½ per cent copper and 7½ per cent antimony).[2]

The approximate physical properties are:

Tensile strength, lb. per sq. in.	10 000
Elongation, per cent	1
Brinell hardness at room temperature	30.2
Brinell hardness at 100° C	15.3
Specific Gravity	7.53

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[1] Research Engineer, The Newton Die Casting Corp., New Haven, Conn.

[2] Subcommittee III on Tin- and Lead-Base Die-Casting Alloys of Committee B-6 on Die-Cast Metals and Alloys is considering the replacement of the alloy, 85 per cent tin, 7½ per cent copper, 7½ per cent antimony by an 83 per cent tin, 5 per cent copper, 12 per cent antimony alloy which appears more advantageous for pressure die castings.

This alloy and similar alloys are used for heavy bearings for the automotive and aeroplane industries, gas meter parts, wheels for meters, medical instruments, parts for milk separators and many other purposes. The tin-rich alloys have the advantage over the alloys containing a higher percentage of lead in that they are superior in strength and in their resistance to tarnishing in the atmosphere. The color of the casting does not change under ordinary atmospheric conditions. In making die castings out of these alloys, the quick cooling action of the water-cooled die on the casting hinders the growing of antimony-rich cubes, thereby producing finer grain size. This is one of the reasons why the physical properties of castings made under pressure are better than those of the same kind of castings produced by other processes.

The alloys of this group are quite expensive due to the high tin content, and considerable work has been done to replace these alloys with those of the second group.

Intermediate Group (*tin and lead-base alloys with antimony and sometimes copper*):

(60 per cent tin, 26 per cent lead, 11 per cent antimony, and 3 per cent copper).

The approximate physical properties are:

Tensile strength, lb. per sq. in.	7 800
Elongation, per cent	1.25
Brinell hardnes at room temperature	27.7
Brinell hardness at 100° C	10.2
Specific gravity	7.98

These alloys and the lead-base alloys in general (groups Nos. 2, 3, and 4) have a lower compressive strength than alloys of group No. 1. The presence of lead in an alloy causes a more rapid softening with increasing temperature.

Lead-Base Alloys (*with tin and antimony*):

(80 per cent lead, 15 per cent antimony, and 5 per cent tin).

The approximate physical properties are:

Tensile strength, lb. per sq. in.	8 000
Elongation, per cent	1.5
Brinell hardness at room temperature	23.2
Brinell hardness at 100° C	10.6

This group of alloys is used for bearing purposes on cheap motor vehicles, small motor bearings, typewriter parts, etc.

It was desired to improve the quality of this group by adding various elements to bring the physical properties nearer to those of group No. 1, having the advantage of a lower price through the lower tin content in the alloy.

It may also be worth while to mention that a German die-casting concern made experiments using an alloy of this class containing also 2.5 per cent copper and 0.4 per cent nickel, holding the casting temperature under 380° C. with the following results:

Substituting part of the antimony with a small amount of nickel, very good results were claimed in regard to hardness and tensile strength of the casting, but the steel die was affected in a manner comparable with the action of a sand blast, showing a pitting of the surface, and after a short while, an expensive die was spoiled and unusable. This result was blamed on the very hard nickel-antimony crystals being thrown against the steel walls of the die

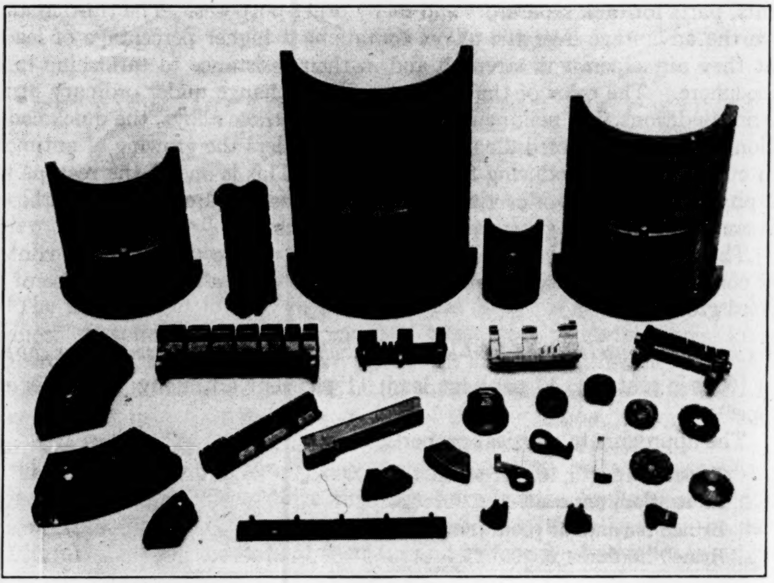

FIG. 1.—Die Castings Made of Lead- and Tin-Base Alloys.

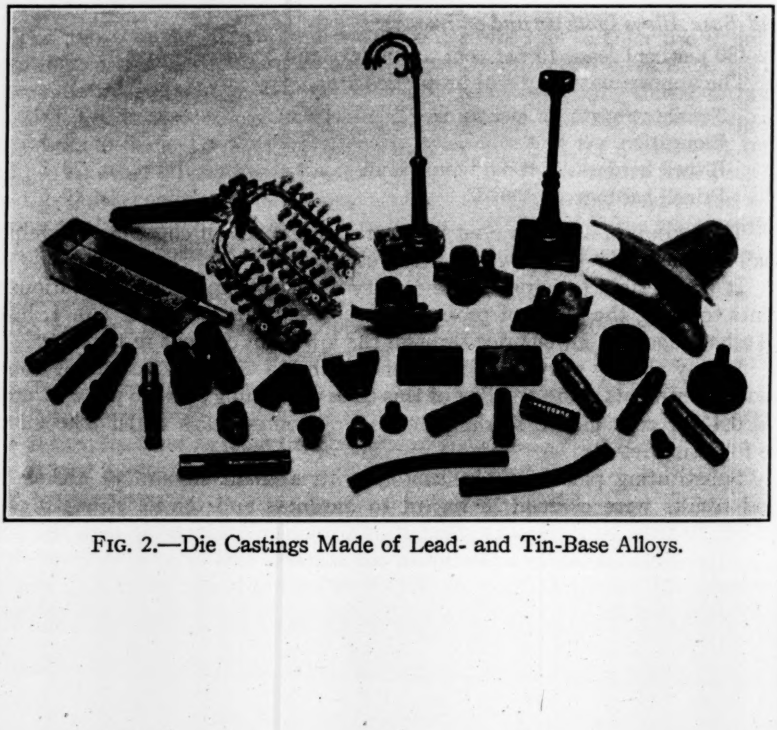

FIG. 2.—Die Castings Made of Lead- and Tin-Base Alloys.

under high pressure. This pitting action might be easily avoided by using the right die steel and the right heat treatment on the die steel.

Lead Antimony Alloys (no tin):

(90 per cent lead, 10 per cent antimony).

The approximate physical properties are:

Tensile strength (approximate), lb. per sq. in.	7 500
Elongation, per cent	1
Brinell hardness	15.5
Specific gravity	10.9

These alloys are used for battery plates, grid terminals, nuts for batteries, windshield corner strips, lead weights, fire extinguisher nozzles, etc.

The hardness of this group of metals varies with the increase of the percentage of antimony. The eutectic alloy contains 13 per cent of antimony. A variation of the physical properties is also possible by adding sodium, magnesium, cadmium, etc.

The disadvantage of the alloys of this group is the higher density of the alloy and the lower resistance against tarnishing under ordinary atmospheric conditions.

It may be stated in general for all four groups of alloys that the following precautions are necessary for producing good die castings:

1. The casting temperature must be held as low as possible;
2. The metal should be agitated in the pot.

The demand for die castings made of these four groups of alloys has lately been increasing. The reason may possibly be that the confidence in die-cast products in general is becoming greater, due to the use of better alloys, better die-casting machines and proper instructions to the users. It is also necessary to bear in mind that the best alloy used in a die casting will give good results in service only if the casting is properly designed. Different die-castings made out of lead- and tin-base alloys are shown in Figs. 1 and 2.

Acknowledgment.—The author wishes to acknowledge and thank Messrs. W. A. Cowan, Assistant Chief Chemist, and G. O. Hiers of the National Lead Research Laboratories, Brooklyn, N. Y., for their assistance in the preparation of this paper.

REFERENCES

References to recently published literature on tin and lead-base die-casting alloys are given below:

(1) W. E. Goodrich, "Volume Changes during Solidification of Metals and Alloys of Low Melting Point," *Transactions*, Faraday Soc., Vol. XXV, Part 10, p. 531, October, 1929.

(2) E. B. Drake, "The Macro-etching of Tin Base Bearing of Metals," *Metals and Alloys*, Vol. 2, No. 1, p. 20, January, 1931.

(3) L. Ackermann, *Zeitschrift für Metallkunde*, Vol. 21, No. 10, p. 339, October, 1929.

(4) Die Legierungen, Ledebur-Bauer, M. Krayn, Berlin W., Germany.

(5) E. Perry, "White Metals Brasses and Bronzes," *The Metal Industry*, Vol. 27, No. 11, p. 509, November, 1929.

(6) William Campbell, "A List of Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 336 (1930).

REPORT OF COMMITTEE B-7

ON

LIGHT METALS AND ALLOYS, CAST AND WROUGHT

Committee B-7 has held two meetings since the publication of the last annual report; one in Dayton, Ohio, on October 16, 1930, and one in Pittsburgh, Pa., on March 19, 1931. Many of the subcommittees held meetings on these same dates.

One new member has been added and one member has resigned, leaving a total membership of 28, classified as 11 producers, 12 consumers, and 5 general interests.

Recommendations Affecting Tentative Standards

The recommendations of the committee affecting tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item. Comments, where necessary, are made under Activities of Subcommittees.

I. *Proposed Tentative Standards.*—The committee submits for publication as tentative the following three specifications:[1]

Proposed Tentative Specifications for Aluminum-Alloy Wire, Rods, and Bars, recommended by Subcommittee III;

Proposed Tentative Specifications for Magnesium-Base Alloy Sheet, recommended by Subcommittee V·

Proposed Tentative Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet), recommended by Subcommittee V.

II. *Proposed Revision of Tentative Standard.*—The committee recommends that the Tentative Specifications for Magnesium-Base Alloy Castings (B 80 - 30 T),[2] as proposed by Subcommittee V, be revised as given in detail in the Appendix, and continued as tentative.

III. *Tentative Standards Advanced to Standard.*—The committee recommends that the following four tentative specifications[1] be advanced to standard with revisions in two as indicated:

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[1] These specifications cover materials which involve patents. They were accordingly referred to the Executive Committee, and their submission for publication as tentative was contingent upon their approval by that committee. See Editorial Note, p. 287.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1003 (1930); also, 1930 Book of A.S.T.M. Tentative Standards, p. 103.

Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet (B 78 – 30 T), without revision as recommended by Subcommittee II;

Tentative Specifications for Aluminum-Manganese Alloy Sheet (B 79 – 30 T), without revision as recommended by Subcommittee II;

Tentative Specifications for Aluminum-Base Alloy Castings (B 26 – 30 T), revised as given in the Appendix as recommended by Subcommittee IV; and

Tentative Specifications for Aluminum-Base Casting Alloys in Ingot Forn (B 58 – 30 T), revised as given in the Appendix as recommended by Subcommittee IV.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Specifications for Aluminum Alloy Wire, Rods, and Bars	10	0	0
Specifications for Magnesium-Base Alloy Sheet	10	0	0
Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet)	10	0	0
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Specifications for Magnesium-Base Alloy Castings (B 80 – 30 T)	13	0	5
III. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Specifications for Aluminum-Alloy (Duralumin) Sheet (B 78 – 30 T)	15	0	3
Specifications for Aluminum-Manganese Alloy Sheet (B 79 – 30 T)	15	0	3
Specifications for Aluminum-Base Alloy Castings (B 26 – 30 T), as revised	17	0	1
Specifications for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T), as revised	17	0	1

ACTIVITIES OF SUBCOMMITTEES

Subcommittee II on Aluminum and Aluminum-Alloy Sheets (R. J. Anderson, chairman).—This subcommittee recommends the advancement to standard of the Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet (B 78 – 30 T) and the Tentative Specifications for Aluminum-Manganese Alloy Sheet (B 79 – 30 T). As a result of consideration by the Executive Committee of the Society of the patent features of Specifications B 78 – 30 T, the usual note regarding patents will be added to these specifications.

Subcommittee III on Aluminum and Aluminum Alloys, Wrought Shapes Other than Sheet (P. V. Faragher, chairman).—This subcommittee has prepared new proposed Tentative Specifications for Aluminum-Alloy Wire, Rods, and Bars and recommends that they be accepted for publication as tentative,[2] as mentioned earlier in the report.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 987 to 1002 (1930); also, 1930 Book of A.S.T.M. Tentative Standards, pp. 87 to 102.

[2] See Editorial Note, p. 287.—ED.

Subcommittee IV on Aluminum-Base Casting Alloys (V. Skillman, chairman).—This subcommittee proposes that the Tentative Specifications for Aluminum-Base Alloy Castings (B 26 – 30 T), and the Tentative Specifications for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T), be revised and brought up to date as given in the Appendix. The word "sand" has been reinserted in the title so as to differentiate this group of alloys from those used in the die-casting industry; alloy K has been deleted; the Explanatory Notes have been rewritten, and various minor editorial changes have been made in order to gain greater clarity and definiteness. Inasmuch as these changes are all of minor importance, this subcommittee recommends that the two specifications as revised be advanced to standard.

TABLE I.—RESULTS OF ANALYSES OF MAGNESIUM ALLOYS.

		Chemical Composition, per cent												
		Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Silicon	Tin	Zinc	Silver	Calcium	Sodium	Nickel
Alloy 1	Aluminum Co. of America	5.94	...	0.01	0.02	[b]	0.17	0.05	...	...	[b]	[b]	[b]	[b]
	Bohn Aluminum and Brass Corp.	6.17	...	0.001	0.02	...	0.13	0.032	...	...	...	...	...	...
	Bureau of Standards	5.95	[a]	<0.01	0.04	[a]	0.14	0.06	...	[a]	...	...	...	...
	Dow Chemical Co.	6.19	...	0.013	0.03	[b]	0.11	0.05	...	[b]	[b]	[b]	[b]	0.011
	Wright Field	6.16	[a]	[a]	0.04	[a]	0.15	0.07	[a]	[a]	...	...	...	trace
	Average Values	6.08	...	0.007	0.03	...	0.14	0.05	...	...	...	...	...	...
Alloy 2	Aluminum Co. of America	8.04	0.76	1.82	0.03	[b]	0.17	0.07	...	0.21	[b]	[b]	[b]	[b]
	Bohn Aluminum and Brass Corp.	8.11	0.62	1.80	0.03	...	0.14	0.05	...	0.15	...	...	...	...
	Bureau of Standards	7.94	0.75	1.83	0.05	[a]	0.15	0.09	...	0.20	...	...	...	...
	Dow Chemical Co.	8.02	0.64	1.80	0.04	[b]	0.13	0.07	...	0.19	[b]	[b]	[b]	[b]
	Wright Field	8.18	0.76	1.83	0.05	[a]	0.16	0.10	[a]	0.20	...	...	...	[a]
	Average Values	8.06	0.71	1.82	0.04	...	0.15	0.08	...	0.19	...	...	...	...
Alloy 3	Aluminum Co. of America	2.04	1.95	3.98	0.01	0.30	0.08	0.04	0.05	0.10	[b]	[b]	[b]	[b]
	Bohn Aluminum and Brass Corp.	1.83	1.84	3.95	0.02	...	0.06	0.02	...	...	...	...	...	...
	Bureau of Standards	1.77	1.98	3.98	0.04	0.31	0.06	0.07	...	0.08	...	...	...	...
	Dow Chemical Co.	1.85	1.87	3.94	0.02	0.27	0.05	0.02	0.06	0.03	[b]	[b]	[b]	[b]
	Wright Field	2.06	2.00	4.00	0.02	0.32	0.07	0.08	0.05	0.07	...	...	...	[a]
	Average Values	1.91	1.93	3.97	0.02	0.30	0.06	0.05	0.05	0.07	...	...	...	...

AVERAGE DEVIATION FROM THE AVERAGE VALUES, PER CENT

	Aluminum	Cadmium	Copper	Iron	Lead	Manganese	Silicon	Tin	Zinc
Aluminum Co. of America	−0.01	+0.03	+0.004	−0.01	0.00	+0.02	−0.01	0.00	+0.02
Bohn Aluminum and Brass Corp.	+0.02	−0.09	−0.015	−0.01	...	−0.01	−0.03	...	−0.04
Bureau of Standards	−0.13	+0.04	+0.008	+0.01	+0.01	0.00	+0.01	...	+0.01
Dow Chemical Co.	0.00	−0.06	−0.015	0.00	−0.03	−0.02	−0.01	+0.01	−0.02
Wright Field	+0.12	+0.06	+0.011	+0.01	+0.02	+0.01	+0.02	0.00	0.00

[a] Not detected by chemical analysis.
[b] Detected by spectroscopic analysis.

Subcommittee V on Magnesium and Magnesium-Base Alloys, Cast and Wrought (J. A. Gann, chairman).—As a result of a demand for guidance as to the best practice, this subcommittee has drafted new proposed Tentative Specifications for Magnesium-Base Alloy Sheet and proposed Tentative Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet), which it recommends be accepted for publication as tentative,[1] as mentioned earlier in the report.

This subcommittee has also revised and brought up to date the Tentative Specifications for Magnesium-Base Alloy Castings (B 80 – 30 T) and recommends that the specifications be revised as given in the Appendix and continued as tentative.

Subcommittee V has likewise conducted an investigation on methods of analytical procedure for magnesium-base alloys. This work consisted in the preparation of three alloys and the distribution of samples to different members of the subcommittee and to the U. S. Bureau of Standards. Each cooperating laboratory used its own methods. The results obtained are tabulated in the accompanying Table I and clearly indicate that sufficient accuracy is readily obtained for commercial and most scientific work. The subcommittee has decided that these data, together with the methods of procedure of the various cooperating laboratories, be referred to Subcommittee VII on Methods of Chemical Analysis of Committee B-2 on Non-Ferrous Metals and Alloys with the recommendation that this material be used as a basis for drafting tentative requirements for methods of analysis of magnesium alloys.

This report has been submitted to letter ballot of the committee, which consists of 28 members; 18 members returned their ballots, of whom 17 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

J. B. JOHNSON,
Chairman.

J. A. GANN,
Secretary.

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[1] See Editorial Note.—ED.

EDITORIAL NOTE

The proposed Specifications for Aluminum Alloy Wire, Rods, and Bars; Specifications for Magnesium-Base Alloy Sheet and Specifications for Magnesium-Base Alloy Wrought Shapes (Other than Sheet) cover materials which involve patents and they accordingly were referred to the Executive Committee for review. Since certain required information has not as yet been obtained, the specifications have accordingly not been accepted for publication as tentative.

The proposed revision of the Tentative Specifications for Magnesium-Base Alloy Castings was accepted. The specifications in their revised form appear on page 700.

The Tentative Specifications for Aluminum-Alloy (Duralumin) Sheet, for Aluminum-Manganese Alloy Sheet, for Aluminum-Base Alloy Castings, as revised, and for Aluminum-Base Casting Alloys in Ingot Form, as revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931. The two latter specifications in their revised form and the two former specifications appear in the 1931 Supplement to Book of A.S.T.M. Standards, pages 21, 24, 29, and 27, respectively.

APPENDIX

PROPOSED REVISIONS IN TENTATIVE STANDARDS FOR LIGHT METALS AND ALLOYS, CAST AND WROUGHT

In this Appendix are given proposed revisions in certain tentative specifications. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

Tentative Specifications for Aluminum-Base Alloy Castings (B 26 - 30 T):[1]

Title.—Change the title of these specifications by the addition of the word "Sand" between the words "Alloy Castings."

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> 1. These specifications cover commercial aluminum-base alloy *sand* castings having a specific gravity of 3 and less. [Eleven] *Ten* alloys are specified and are designated alloys A to ***H, inclusive, and J and*** K (see Note 1).

Section 5.—In this section omit the reference to Note 2.

Section 6.—Change from its present form: namely.

> 6. (*a*) Two test bars shall be an integral part of large castings, or cast separately in the case of small castings to represent a lot or melt, and shall be molded in a manner similar to the castings which they represent. If the castings are heat treated, the test bars representing such castings shall be similarly heat treated.
>
> (*b*) The manufacturer and purchaser shall agree whether the test bars can be attached to castings, on the locations of the bars, on the castings to which bars are to be attached, on the method of casting unattached bars and whether a "cast-to-size bar" or a "machined-to-size bar" shall be used (see Note 2).
>
> (*c*) The "machined-to-size bar" shall be cast according to the dimensions shown in Fig. 1, and machined to conform to the dimensions shown in Fig. 2. The "cast-to-size" bar shall be cast according to the dimensions shown in Fig. 2 and shall be tested without machining. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial (see Note 3).

to read as follows:

> 6. The test bars shall be separately cast in green sand and shall be "cast to size" according to the dimensions shown in Fig. 1. If the castings are heat treated, the test bars representing such castings shall be similarly heat treated.

---

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 997 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 97.

They shall not be machined prior to test except to adapt the grips to the holders of the testing machine in such a manner as to insure an axial load.

Section 7 (a).—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> **7.** (a) ***The*** tests shall, [as] *so* far as possible, be made by heats or melts, but, unless otherwise agreed upon, two tension tests shall be made [upon] *for* each unit [lot] of 500 lb. or [single delivery of less than 500 lb.] *fraction thereof.*

Table I.—Change the title of this table by the addition of the word "Sand" before the word "Castings."

Change alloys C and D by the addition of the word "trace" for magnesium and a requirement of 0.3 per cent, maximum, for manganese.

Increase the maximum manganese requirement for alloy F from "0.2 per cent" to "0.3 per cent" and add a requirement of 0.3 per cent, maximum, for other impurities.

Add a requirement of 0.3 per cent, maximum, manganese for alloy H and increase the present requirement for other impurities from "0.2 per cent" to "0.3 per cent," maximum.

Delete all the requirements for alloy K and reletter alloys I and J as alloys J and K, respectively.

To the words "trace" in the column of magnesium requirements add the following footnote:

> For the purpose of these specifications "trace" shall be considered as not over 0.05 per cent.

Table II.—Change the title of this table by the addition of the word "Sand" before the word "Castings." Delete alloy K from this table and reletter alloys I and J as alloys J and K, respectively.

Figure 1.—Delete Fig. 1 showing the ⅝-in. by 2¼-in. test specimen and renumber the present Fig. 2 as Fig. 1.

Explanatory Notes.—In Note 1 change the paragraphs relating to Alloys B, D, F, G, H, I, J and K to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> Alloy B.—*This* alloy [B] has [approximately the same] *a* specific gravity [and shrinkage as Alloy A] *of about 2.83. The pattern shrinkage is about 0.156* ($\frac{5}{32}$) *in. per ft.* It is superseding Alloy A as it possesses better casting characteristics, especially in the more difficult work where higher pouring temperatures than those usually employed are found necessary. The tendency towards cracks and [shrinkage] *shrinks* is considerably overcome by the careful control of the iron and silicon contents. This alloy is used for general casting purposes.
>
> Alloy D.—*This* alloy [D is very similar to Alloy C in both properties and uses] *has a specific gravity of about 2.83.* Due to its higher silicon content it has greater fluidity and is less subject to cracking. It is used for the more intricate general casting work.

Alloy F.—The specific gravity of *this* alloy [F] is about 2.90 and the pattern skrinkage about 0.156 ($\frac{5}{32}$) in. per ft. The alloy is used for pistons, *cylinder heads*, valve guides, and bearings or other parts where hardness and good bearing qualities are essential. *Together with Alloy H it possesses the property of retaining at higher temperatures a greater percentage of its room temperature strength than any other alloy in this group. This alloy may be heat treated, in which case substantially higher strength and hardness or other desirable characteristics are obtained.*

Alloy G.—*This* alloy [G] has a specific gravity of about 2.78. It is for general casting purposes where *a combination of* lightness, [and] higher strength *and ductility* is desired. [It is more resistant to corrosion than the other copper alloys.] The various strengths are obtained through different heat treatments. Heat Treatment No. 1 gives maximum elongation and resistance to shock. It is a solution heat treatment and may be specified where the most rugged service is required. An aging effect takes place on standing which increases the strength and slightly decreases the elongation. Heat Treatment No. 2 is a solution and precipitation heat treatment, and should be specified where a higher initial strength, yield point and hardness are desired. Heat Treatment No. 3 should be specified where the highest strength *and hardness* [is] *are* desired *and lower ductility is not objectionable.* This alloy *with the various heat treatments* is used in general for high strength parts in street cars and busses, parts for internal combustion engines, outboard motor parts and other marine castings.

Alloy H.—The specific gravity of *this* alloy [H] is *about* 2.80. It is usually [used] *employed* in the heat-treated condition. [It has advantage over the copper alloys of retaining more of its strength at elevated temperatures. This property makes the alloy useful for aircraft cylinder heads and pistons.] *The alloy is used for pistons, cylinder heads, valve guides and bearings or other parts where hardness or good bearing qualities are essential. Together with Alloy F it possesses the property of retaining at higher temperatures a greater percentage of its room-temperature strength than any other alloy in this group.*

Alloy [I] *J.—This* alloy [I] is somewhat lighter than aluminum, having a specific gravity of *about* 2.69. It withstands corrosion better than the copper alloys. The free flowing property of the alloy when molten makes it easier to pour castings of thin section or intricate design. *Its leak proof properties are valuable where pressure tightness is essential.* It has a lower strength and yield point than the copper alloys and poorer machining qualities. It is especially suitable for automobile body parts, cooking utensils, *architectural*, and marine castings.

Alloy [J] *K.*—The specific gravity of *this* alloy [J] is *about* 2.68. Immediately before pouring, the alloy is treated by a process called "modification." Its corrosion resistance is good, especially to salt water. It has good foundry characteristics and can be used for castings having both thin and heavy sections. It is not as readily machined and has a lower yield point in proportion to tensile strength than most of the copper alloys. It is used for [architectural and] marine castings, bus, street car and engine parts, and for thin castings such as radiators, small motor housings and meter cases.

[Alloy K.—Alloy K has good casting characteristics and a higher yield point than the silicon alloys without copper. It is used more extensively for match plate and pattern work.]

Notes 2 and 3.—Omit these notes which read as follows:

NOTE 2.—Some latitude has been allowed in the matter of test specimens; test bars "cast to size" are stronger than those which are "machined to size" and the tensile properties specified are regularly obtained in commercial production only with the "cast-to-size" bar. When "machined-to-size" specimens are required to meet the values given in these specifications, rejections may be expected to run higher than those experienced in usual commercial production. Owing to insufficient information being available on the tensile properties of "machined-to-size" specimens it was not possible to include a separate table of values for this type of specimen.

NOTE 3.—It is strongly recommended that a self-centering form of tension test specimen holder be used. Most aluminum alloys are brittle and given lower and less uniform test results when tested in ordinary wedge grips without centering.

Tentative Specifications for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T):[1]

Title.—Change the title of these specifications by the addition of the word "Sand" before the word "Casting."

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

1. These specifications cover commercial aluminum-base *sand* casting alloys in ingot form for remelting. The specific gravity of these alloys does not exceed 3.0. [Eleven] *Ten* alloys are specified and are designated alloys A to *H, inclusive, and J and* K (see Explanatory Note).

Table I.—Make the same changes in this table as recommended in Table I of Specifications B 26 – 30 T above and also in the column under Remarks change the iron plus silicon requirement for alloy F from "2 per cent" to "1.8 per cent."

Explanatory Notes.—Replace the present explanatory notes with the following note:

NOTE.—Explanatory notes pertaining to the alloys covered by these specifications when used in the form of sand castings are given in connection with the Standard Specifications for Aluminum-Base Alloy Sand Castings (A.S.T.M. Designation: B 26 – 31) of the American Society for Testing Materials.

Tentative Specifications for Magnesium-Base Alloy Castings (B 80 – 30 T):[2]

Section 1.—Transfer the notes following this section to the end of the specifications and change from their present form: namely,

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 993 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 93.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1003 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 103.

NOTE.—Alloy No. 1 is the most widely used alloy, and is recommended for general casting work.

Alloy No. 2 possesses a higher yield point and greater hardness. Considerable latitude has been allowed in the chemical composition, as similar properties in the cast alloys can be obtained from different compositions. The copper content should be kept low where maximum corrosion resistance is desired.

Alloy No. 3 has a thermal conductivity 50 to 75 per cent greater than Alloys Nos. 1 and 2, and is recommended where this property is of great importance.

to read as follows:

Alloy No. 1.—Alloy No. 1 has a specific gravity of about 1.78. It is used only in the as-cast condition. The copper content should be kept as low as possible in order to minimize corrosion.

Alloy No. 2.—Alloy No. 2 has a specific gravity of about 1.80. It is susceptible to heat treatment and is used both in the as-cast and heat-treated conditions. The most beneficial effects of heat treatment are reflected in the increase in tensile strength, percentage of elongation and notched-bar impact toughness. The copper content should be kept as low as possible in order to minimize corrosion.

Alloy No. 3.—Alloy No. 3 has a specific gravity of about 1.82. Its thermal conductivity is 50 to 75 per cent greater than that of Alloys Nos. 1 and 2 and is recommended where this property is of great importance.

Section 3.—In the first sentence of this section change Alloy No. 1 to read Alloy No. 2.

Section 4.—Change the table of chemical composition in this section from its present form: namely,

Alloy	Magnesium, minimum, per cent	Aluminum per cent	Manganese, minimum, per cent	Copper, per cent	Cadmium, per cent	Silicon, maximum, per cent	Remarks
No. 1....	90	5.5 to 8.5	0.2	0.1, max.	1.0, max.	0.2	Other metals, 0.3 per cent, maximum
No. 2....	87	8 to 12	0.1	2.5, max.	....	0.2	Other metals, 2.5 per cent, maximum
No. 3....	91	1.7 to 2.3	0.2	3.5 to 4.5	1.6 to 2.4	0.2	Other metals, 0.3 per cent, maximum

to read as follows:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese minimum, per cent	Copper, per cent	Cadmium, per cent	Other Impurities, maximum, per cent
No. 1..............................	remainder	5.5 to 7.0	0.2	0.1, max.	....	0.3
No. 2..............................	remainder	6.5 to 8.5	0.2	0.1, max.	....	0.3
No. 3..............................	remainder	1.7 to 2.3	0.2	3.5 to 4.5	1.6 to 2.4	0.3

Section 6.—Change the table of tensile properties in this section from its present form: namely,

ALLOY	CONDITION	TENSILE STRENGTH, MINIMUM, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
No. 1	Sand Cast	24 000	4
	Sand Cast, Heat Treated	29 000	6
No. 2	Sand Cast	20 000	0.5
No. 3	Sand Cast	21 000	2

to read as follows:

ALLOY	CONDITION	TENSILE STRENGTH, MINIMUM, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
No. 1	Sand Cast	24 000	4
No. 2	Sand Cast	24 000	4
	Sand Cast, Heat Treated	29 000	6
No. 3	Sand Cast	21 000	2

REPORT OF COMMITTEE C-1

ON

CEMENT

Committee C-1 on Cement has busied itself largely during the year; first, in completing its reorganization; second, in studying the nature of the researches which it must originate and get under way; and, third, in giving very thorough consideration to the desirability of employing someone who will give his full time to studying and keeping the committee informed of the attitude of those interested in cement towards the Society's specifications and methods of tests covering cement.

The committee is now organized into subcommittees on methods of testing, on high-early-strength cement, on masonry cement, and on portland cement. It is, therefore, in an excellent position to give the proper attention to each of these subjects without unduly slighting any one of them. Special attention has been paid to bringing into these several subcommittees those who are most interested in the problems or materials with which the particular subcommittee is concerned. In order to more properly round out the personnel of these groups, attention has been paid to increasing the membership of the committee to the limit permitted by its by-laws, through the addition of those who are especially interested in the several new aspects of the committee's work.

The committee has not made the hoped-for progress in getting its studies under way. It is probable that the thought of making its researches somewhat more fundamental than heretofore has not yet been fully absorbed by the committee as a whole. But it is still the belief of those guiding its functioning, that it should busy itself in determining what is demanded of a cement in its several uses; then what tests will best indicate that the cement will meet these demands; and then how these tests should be carried out. Until such viewpoints have been fully adopted, it is possible that the committee will show rather slow progress. It is interesting to note, however, that the discussions developed during the two meetings of the committee held during the year have evidenced that the members are rapidly realizing the desirability of such more basic starting points than it has previously used.

The committee has asked and obtained from the Executive Committee of the Society its approval for employing what may be called an "interpreter and guide"—both to it and the industry. His duties will be to keep the committtee and the interested public informed on the status of, and the developments in, cement specifications and methods of test used throughout the country. It has been felt for some time that the contacts between the committee and the public concerned with cement were not as close as they should be. The number of types of cements are increasing. The uses of any one of these types are extending. The consuming public is not only being constantly enlarged, but it is becoming more exacting in its demands. Even though the committee membership extends over the entire country, it cannot obtain and maintain the direct contacts that are needed to keep it and the public informed of one another's activities. Therefore, this full-time paid employee will be used to present to those who have created or are discussing departures from the Society's standards, the results of the studies and the whole background upon which the committee has based its findings. He will at the same time obtain, and, if possible, bring back to the committee the data and reasoning upon which departures are based. He will be in an advisory way at the service of those who feel they would like a direct personal contact with the Society's activities in the field of cement standards. He will also have the duty of seeing that the several subcommittees are expeditiously carrying out the work which has been assigned to them, and that they are particularly giving prompt consideration to matters referred to them by the contacts which he has created outside the committee membership. Since it is known that the Society cannot help the undertaking financially, a finance committee has been appointed to raise the needed funds. All members of the committee and others in the producing and consuming interests will be solicited.

The committee has again given thought to the Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars (C 9 - 16 T) and recommends that they be continued as tentative for another year.

The committee has had its attention called to the fact that in separating the specifications from the methods of testing and issuing each as individual standards, certain details were lost sight of—particularly the lack of indicating in the specifications the tolerances in certain requirements. It is believed, however, that the correction of this and certain other defects of a somewhat similar nature can be carried out as editorial matters in subsequent issues of the standards, and hence do not require formal action on the part of the committee or the Society.

SUBCOMMITTEE ACTIVITIES

Subcommittee on Cement Reference Laboratory.—The Cement Reference Laboratory has continued its work along the lines which were developed last year. A report of this subcommittee is appended hereto. By the time of the annual meeting of the Society many of the laboratories visited last year will have been revisited. Then it will be possible to analyze somewhat more critically the results of this work and how it has been received. Up to the present, the results of the work have been evaluated largely through the criticisms obtained from letters and comments received in connection with the reports which have been issued. A great majority of these comments have been most encouragingly commendatory and indicate an outstanding appreciation of the laboratory's efforts. But the real value of the work can be judged better possibly by the inspectors on their second visits to the laboratories. They can then estimate how many of their previous recommendations have been heeded and put into use. It should be acknowledged now that it has been found that a very few of the laboratories which have been revisited have not given any great attention to the previous recommendations of the inspectors—one laboratory has not yet provided itself with other than an obsolete copy of the specifications.

Subcommittee C on High-Early-Strength Cement.—The committee has not received many comments regarding the Tentative Specifications for High-Early-Strength Portland Cement (C 74 – 30 T). Those which have been received indicate that the strength requirement at the end of 24 hours is possibly too high. The committee is not now aware of the quantities of these cements which are being purchased, tested, and accepted according to the Tentative Specifications C 74 – 30 T and is therefore lacking in the information needed before it can seriously consider any modifications. The Subcommittee on High-Early-Strength Cement will doubtlessly give consideration to those cements developing high-early strength which are not included in the present tentative specifications, due to their not meeting the definition of portland cement because of their composition. It is recommended that the Tentative Specifications for High-Early-Strength Portland Cement (C 74 – 30 T) be continued as tentative.

Subcommittee D on Masonry Cement.—This subcommittee is making an earnest effort to present to the committee at this meeting proposed tentative specifications for masonry cement. It has been delayed somewhat, due to the need of closer study of the question of amount of water to be used in making the test specimens. This has been just as much a matter of considerable moment with this type of cement as it has been with portland cement. Indeed, the problem is rather more acute, since the masonry cements as a type include those having a greater divergence of properties than is found among the portland cements. With this standard before the public, the committee will have filled a much needed want. The growth of the usage of this type of cement in the past few years has indeed been surprising.

Committee members attending the meeting on June 24 unanimously voted to add to this report the following paragraph:

Since available data indicate that a variation in temperature of cement of as much as 100° F. affects the temperature of the concrete less than 10° F., it is recommended that, pending the results of further investigations and conclusions by Committee C-1, regulations governing the temperature of cement be held in abeyance.

This report has been submitted to letter ballot of the committee, which consists of 74 members; 67 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

P. H. BATES,
Chairman.

F. H. JACKSON,
Secretary.

REPORT OF SUBCOMMITTEE ON CEMENT REFERENCE LABORATORY

During the past year the field inspection of cement laboratories has continued to be the major activity of this subcommittee. Between April 17, 1930, the last date covered in the 1930 report,[1] and December 1, 1930, there were received 42 additional requests for inspection. From December 1, 1930, when arrangements were being made for the second field tour, to April 6, 1931, requests for inspection were received from 186 laboratories, of which 129 had been previously inspected. The location and classification of the laboratories cooperating in this work are shown in Table I. A study of this table furnishes some comparison of the interest shown in the first and second inspection tours. The state highway laboratories have been included under the same heading as universities and schools, since in some instances they are identical. In Table I, approximately 25 state highway laboratories are included in the portion of the table prior to December, 1930, and about 28 in the later part.

Since December 1, 1930, the field inspections have been largely in the eastern and southern states. The next inspections will be in the New England and the southwestern districts. By the end of June, about fifty additional inspections will have been made.

The quantity of apparatus inspected during the past year is shown in Table II. Prior to the inspector's visit, each laboratory is now receiving a short circular inviting attention to certain details of equipment and advising where tolerances for apparatus may be found. There has been considerable correspondence with both producers and users of laboratory equipment.

The data collected in the field have served to furnish a list of items to Subcommittee A on Methods of Testing for consideration in connection with the revision of the manual. Also, the survey of the first several hundred laboratories provided material for a report on laboratory equipment and methods presented by Messrs. P. H. Bates and J. R. Dwyer at the annual meeting of the Portland Cement Association in November, 1930.[2]

The second inspection of a laboratory affords some idea of the results of the first visit. It is too early to make any extensive comparisons, although it has been noted that some laboratories have shown appreciation of the work, and have improved both methods and apparatus, while some others have apparently paid but little attention to the first report. The reports of the second inspections are inviting attention to any persistence of unsatisfactory conditions enumerated in the first report. All of the blame for lack of correction of deviations from standard must not be placed upon the physical tester, since it is very evident that there is sometimes too little contact between the directors of laboratories and their staff. The labors

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 426 (1930).

[2] "Minutes of the Mill Session," Portland Cement Assn., November, 1930.

TABLE I.—LOCATION AND CLASSIFICATION OF CEMENT TESTING LABORATORIES REQUESTING INSPECTIONS.

State	Up to November 30, 1930						From December 1, 1930, to April 6, 1931					
	Producers	Commercial	Schools and State Highways	Municipal	Miscellaneous	Total	Producers	Commercial	Schools and State Highways	Municipal	Miscellaneous	Total
Alabama	3	1	..	..	..	4	3	2	..	..	..	5
Arizona	..	..	..	..	..	..	..	..	1	..	..	1
Arkansas	..	..	1	..	..	1	..	..	..	..	..	..
California	8[a]	3	1	4	1	17	6	3	2	2	1	14
Colorado	2	1	2	..	1	6	..	1	2	..	1	4
Connecticut	..	1	..	..	..	1	..	1	2	..	..	3
District of Columbia	..	..	..	..	1	1	..	..	..	..	..	..
Florida	1	1[b]	1	..	..	3	1	..	1	..	..	2
Georgia	1	1	1	..	..	3	2	..	1	..	..	3
Idaho	1	..	1	..	..	2	1	..	1	..	..	2
Illinois	3	3	2	..	..	8	3	2	2	..	..	7
Indiana	4	..	1	..	..	5	2	..	1	..	..	3
Iowa	5	1	..	..	..	6	1	..	4	..	..	5
Kansas	3	..	1	..	..	4	4	..	1	..	..	5
Kentucky	1	..	1	1	..	3	..	..	1	..	..	1
Louisiana	..	1[b]	..	..	..	1	..	..	1	..	..	1
Maine	1	..	1	..	..	2	1	..	1	..	..	2
Maryland	2	1	..	..	..	3	1	..	..	..	..	1
Massachusetts	..	2	2	..	..	4	..	..	3	..	..	3
Michigan	5	4	2	..	..	11	9[b]	2	3	1	..	15
Minnesota	1	1	3	1	..	6	1	..	2	..	..	3
Missouri	4	1	3	1	..	9	5	1	1	1	..	8
Montana	..	..	..	..	..	..	..	..	1	..	..	1
Nebraska	..	..	..	..	..	..	..	1	..	..	..	1
Nevada	..	..	1	..	..	1	..	..	1	..	..	1
New Hampshire	..	1	1	..	..	2	..	..	..	..	..	..
New Jersey	2	..	2	1	..	5	1	..	1	..	..	2
New York	9	3	1	1	..	14	7	2	2	2	..	13
Ohio	6	7	2	..	..	15	8	1	1	..	..	10
Oklahoma	..	1	1	..	..	2	1	1	..	..	..	2
Oregon	2	..	1	1	..	4	3	..	2	..	..	5
Pennsylvania	21[a]	6	3[b]	..	1	31	14	2	7	1	1	25
Rhode Island	..	..	2	..	..	2	..	..	1	..	..	1
South Carolina	..	..	..	..	..	..	..	1	3	..	..	4
South Dakota	..	..	2	..	..	2	..	..	1	..	..	1
Tennessee	5	..	1	..	1	7	6	2	1	..	..	9
Texas	6	7	2	..	..	15	10	..	1	..	..	11
Utah	2	..	1	1	..	4	..	..	..	..	..	..
Virginia	1	1	..	..	..	2	..	1	2[b]	..	..	3
Washington	4	1	2	..	..	7	3	2	..	..	..	5
West Virginia	2	..	..	..	..	2	2	..	..	..	..	2
Wisconsion	1	..	1	..	..	2	1	..	..	..	..	1
Wyoming	..	..	..	..	..	..	1	..	..	..	..	1
Total Requests	106	49	48	11	5	219	97	25	54	7	3	186
Inspections completed April 6, 1931	101	46	46	11	5	209	28	4	8	2	1	43
Cancelled	4	2	1	..	..	7	1	..	1	..	..	2
Inspections to be made	1	1	1	..	..	3	67	20	48	5	2	142
Second Inspections requested	..	..	..	..	..	..	79	13	29	5	3	129

[a] Of this total, two cancellations were made.

[b] Of this total, one cancellation was made.

of committee members and the endeavors of inspectors are not always reflected in the actual laboratory work of the men who should be influenced thereby. For example, the criticisms and suggestions of the inspection reports are not always made known to the operators. Again, in 1931 a laboratory under the supervision of a man greatly interested in cement testing was using a copy of the 1920 edition of the Standard Specifications and Tests for Portland Cement, although two revisions have been made of that standard since 1920.

Comparative samples have not been distributed since there was desired a clearer idea of the field involved. Some samples will be distributed at an early date. Necessarily it does not appear profitable to send samples to such laboratories as are shown by second inspections to maintain conditions and methods considerably different from standard.

TABLE II.—APPARATUS INSPECTED FROM APRIL 18, 1930, TO APRIL 6, 1931.

	INSPECTED IN FIELD		INSPECTED AT BUREAU	
	OBSERVED	APPROVED	OBSERVED	APPROVED
Steam chests	127	76	...	...
Balances for fineness	153	62	1	1
Balances for mixes	178	125	...	...
Weights for fineness, pieces	1270	1216[a]	16	16
Weights for mixes, pieces	1980	1909[a]	...	...
Graduates	368	317	...	...
Vicat apparatus	163	61[a]	5	5
Gillmore needles, pairs	174	73[a, b]	3	3
Briquet molds	4378	3363[a]	223	212
Tensile machines	136	71[a, c]	2	2
Total	8927	7273	250	239

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[a] Includes apparatus satisfactorily adjusted during inspection.

[b] Since January 1, 1930, tapered end Gillmore needles have not been accepted on basis of micrometer measurements.

[c] Includes some grips not in accordance with all details of standard specifications, but of type and dimensions considered satisfactory.

It is probable that temperature variations continue to be a source of much divergence in test results. Numerous laboratories have given this matter their attention, and have improved their moist cabinets, although not very many have installed automatic temperature control on the tanks and cabinets. The importance of storage temperature control is shown in Table III.

Considerable work has been done on the study of air separating devices in the effort to secure an apparatus suitable for furnishing sharply defined fractions of cement in appreciable quantities in order to study the effects of variations in gradation and assist in the investigation of methods for making quick fineness analyses of material too small for the usual sieves.

A short 16-mm. film, demonstrating the cement testing methods, has been prepared and has been shown in some laboratories. While this first attempt is somewhat experimental, one of the state universities has decided to secure a copy to use in their laboratory work.

TABLE III.—TEMPERATURES OBSERVED AT VARIOUS LABORATORIES.

LOCATION	NUMBER OF LABORATORIES	TEMPERATURE, DEG. CENT. AVERAGE	MAXIMUM	MINIMUM
Tank	184	20.8	27.3	7.5
Cabinet	189	22.1	32.0	11.7
Room	187	23.2	36.8	11.0
Tap water	184	16.3	36.0	3.0
Outdoors	183	16.1	38.3	−23.0

While the inspectors feel that they are promoting uniformity and improvement, it must be admitted that not all laboratories are equally interested in the work of the Cement Reference Laboratory, even though they may have requested inspection. One laboratory considered that departures from the standards should not be criticised unless comparative tests showed these variations to be of importance. Some other laboratories apparently have little or no interest in the work. It appears that rapid improvement in the methods of testing cement will depend greatly on the concerted and continuous endeavors of the more interested laboratories.

Respectfully submitted on behalf of the subcommittee,

F. W. KELLEY,
Chairman.

REPORT OF COMMITTEE C-3

ON

BRICK

Committee C-3 on Brick held two general meetings during the past year; at Atlantic City, N. J., on June 25, 1930, and at Washington, D. C., on April 3, 1931.

The attention of the committee for the past year has been directed on the problem of measures and classifications for resistance to weathering. Several members of the committee are at present carrying out laboratory investigations on weathering and have reported their progress to the committee. Committee C-3 is, however, not yet prepared to make recommendations for a revision of the various specifications under its jurisdiction with respect to adding classifications based on weathering resistance.

Committee C-3 has jurisdiction over two tentative standards, namely, Tentative Specifications for Concrete Building Brick (C 55 – 28 T), and Tentative Methods of Testing Brick (Compression, Flexure and Absorption) (C 67 – 30 T). The committee makes the following recommendations with reference to these tentative standards:

Advancement of Tentative Standard to Standard.—It is recommended that the Tentative Methods of Testing Brick (Compression, Flexure and Absorption) (C 67 – 30 T)[1] be advanced to Standard without revision.

Tentative Standard Continued as Tentative.—It is recommended that the Tentative Specifications for Concrete Building Brick (C 55 – 28 T) remain as tentative for another year. This recommendation results from the inability of the committee to agree with respect to the sufficiency of the present available data on the performance of concrete brick with respect to the relation between brick strength and strength of masonry. It is hoped that additional data will be available in the future.

The recommendation for the advancement of the tentative standard to standard has been submitted to letter ballot of the committee with the following result:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1033 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 198.

Item	Affirmative	Negative	Not Voting
ADVANCEMENT OF TENTATIVE STANDARD TO STANDARD			
Tentative Methods of Testing Brick (Compression, Flexure and Absorption) (C 67 – 30 T)	34	0	0

This report has been submitted to letter ballot of the committee, which consists of 38 members; 34 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. T. SHELLEY,
Chairman.

J. W. MCBURNEY,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Testing Brick (Compression, Flexure and Absorption) were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931, and appear in the 1931 Supplement to Book of A.S.T.M. Standards, page 65.

REPORT OF COMMITTEE C-5
ON
FIRE TESTS OF MATERIALS AND CONSTRUCTION

Committee C-5 is engaged in studying methods for conduct of fire tests of lumber, applicable both to chemically-treated lumber and to lumber in its natural state.

The progress report presented by the committee to the Society in June of last year carried an illustrated description of an instrument which has been developed at the Forest Products Laboratory for experimental work of this kind.[1] The equipment is on display in the Exhibit of Testing Apparatus and Machines which is a feature of the annual meeting of the Society this year.

During the past twelve months the apparatus has been placed in the hands of several experimenters in various localities for practical trial. While it has not yet been possible to secure and digest test results developed with the equipment from all of these sources, the experience of certain of those who have been using the instrument indicates that it has distinct practical utility and forecasts that use of the instrument will probably be prescribed in a tentative standard to be presented later to the Society by the committee, perhaps in connection with companion tests of other kinds.

Committee C-5 has responsibility for only one existing tentative standard, namely, the Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 – 26 T). In the earlier drafts, these specifications were the work of Committee C-5. Later they were taken in hand and developed into their present form by the Sectional Committee on Fire Tests of Materials and Construction functioning under the American Engineering Standards Committee, now the American Standards Association. Since their adoption as tentative by the Society they have been used by certain testing bodies for guidance in conducting tests on subjects which lie within their scope. However, they are applicable to test subjects in very considerable variety, and there are many subjects on which they have not as yet been given adequate practical trial. The sectional committee, which conducted the later development work on the specifications, has not met during the past year for revision or extension of its past work; but during its later sessions recognized that frequent revision would be unwise because of its effect on the status of classifications derived from tests conducted in accordance with the present text. Under these circumstances, it has been the opinion of Committee C-5 that the specifications have correct status as tentative, and it is therefore recommended that for the present the Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 – 26 T) be continued as tentative without revision.

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[1] See Proposed Method of Test for Fire-Retardant Treated Wood, *Proceedings*, Am. Soc. Testing Mats., Vol. 30, **Part I**, p. 463 (1930).

A new subcommittee is being organized, namely, Subcommittee III on Fire Tests of Wall Opening Protectives, to consider formulation of standard methods for conduct of fire tests on fire doors and perhaps fire stops of other kinds for protection of wall openings against passage of fire. The subcommittee as constituted at present comprises the following:

A. H. Beyer, chairman, R. C. Bastress, C. F. Burt, G. E. Strehan, and Fitzhugh Taylor.

It is expected that the new subcommittee will shortly commence preliminary work on its assignment.

This report has been submitted to letter ballot of the committee, which consists of 21 members; 20 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

RUDOLPH P. MILLER,
Chairman.

FITZHUGH TAYLOR,
Secretary.

REPORT OF COMMITTEE C-7
ON
LIME

Committee C-7 on Lime has held three regular meetings since the presentation of its last report in 1929. The first was held during the annual meeting of the Society in June, 1930, at Atlantic City, the second in Philadelphia during November of the same year and the third in connection with the Group Meeting of A.S.T.M. Committees in Pittsburgh in March, 1931. In addition, a special meeting of the Advisory Committee was held in Philadelphia in September, 1930.

As a result of a thorough canvass of the committee personnel, made for the purpose of stimulating interest in important activities, a general reorganization of Committee C-7 was effected. New chairmen of subcommittees were appointed, new projects introduced and better cooperation was attained, all of which resulted in a smoother functioning of the committee as a whole.

The Subcommittee on Lime Plastering of the Sectional Committee on Specifications for Plastering, functioning under the procedure of the American Standards Association, reports progress in the preparation of specifications for lime plastering. The chairman of this subcommittee, Mr. J. A. Murray, is also a member of Committee C-7.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Standard Specifications for Hydrated Lime for Structural Purposes (C 6 - 24).[1]—The committee recommends the advancement to standard of a portion of the pending tentative revision in these standard specifications. The portion recommended for adoption is given in detail below and includes the omission of the last paragraph in Section 13, a revision of the constants under the illustration of the Emley Plasticimeter in Fig. 1, and the addition of two new sections as Sections 14 and 15. The committee also recommends that the remaining portion of the tentative revision[2] affecting Sections 12 and 13 of these specifications be continued as tentative.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 51.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1273 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 785.

Section 13.—Omit the last paragraph of this section reading as follows:

> After each test, the porcelain base plate shall be washed with hot water, treated with dilute hydrochloric acid to remove any lime from the surface pores, washed again with water, to remove the acid, dried by heating above 100° C., and cooled to room temperature before it is used again.

Figure 1.—Revise the constants given under the illustration of the Emley Plasticimeter by changing the first line from its present form: namely,

> *Absorption of porcelain base plate.*—20 to 25 per cent.

to read as follows:

> *Absorption of porcelain base plate.*—Minimum 40 g. in 24 hours. For rate of absorption of base plates, see Section 15.

Add two new sections, numbered 14 and 15, to read as follows, renumbering the present Section 14 to read Section 16:

14. *Cleaning and Care of Base Plates.*—In making plasticity determinations much of the success attainable depends upon the condition of the base plates. Continued use of the plates without proper cleaning results in clogging of the pores, with reduction in the rate of absorption. After a plate has been used the excess lime shall be wiped off and the plate immersed in clear water for not less than two hours, after which it shall be transferred without drying to a dilute solution of hydrochloric acid (1:9) where it shall be kept immersed for another two hours. It should then be transferred to a receptacle containing running water for at least one hour. The plate is then free of acid and after the removal of excess water should be placed in an oven at a temperature of between 100 and 110° C. overnight for drying. Before using, the plate shall be cooled to room temperature.

15. *Absorption of Plasticimeter Base Plates.* (*a*) *Total Absorption.*—Plasticimeter base plates when immersed in water at room temperature for a period of 24 hours shall absorb not less than 40 g. of water. Before making the determination the plates shall be dried overnight in an oven at a temperature of between 100 and 110° C. and permitted to cool to room temperature. After immersion and before weighing, the excess water shall be wiped off with a damp cloth.

(*b*) *Rate of Absorption.*[a]—When tested over an area 2¾ in. in diameter the water absorbed shall be in accordance with the following:

	WATER ABSORBED, CC.
First Minute	8 to 14
Second Minute	5 to 7½
Third Minute	4 to 6½
Fourth Minute	4 to 6
Fifth Minute	3½ to 5½

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[a] A convenient apparatus for determining the rate of absorption consists of a burette sealed onto an inverted glass funnel from which the stem has been removed. The diameter of the larger end of the funnel shall be ground so as to be 2¾ in. in internal diameter. The funnel may be attached to the plate on which the measurement is being made by melted paraffin. The paraffin should not be too hot. A little experience will indicate when it is of the proper consistency.

Tentative Specifications for Sand for Use in Lime Plaster (*C 66 – 27 T*).[1]—The committee recommends that the following revisions in these specifications be approved and that the specifications as thus revised be continued as tentative for another year:

Section 3.—In the table of requirements for grading, add the following requirement for the percentage of material to be retained on a No. 4 sieve and change the requirement for a No. 50 sieve to read as follows, by the addition of the italicized figure and the omission of the figure in brackets:

Retained on a No. 4 (4760-micron) sieve........	none
Retained on a No. 50 (297-micron) sieve......	not more than 95 per cent not less than [20] *70* per cent

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT TO STANDARD OF TENTATIVE REVISIONS OF STANDARD			
Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 24)..........	13	2	2
II. PROPOSED REVISION OF TENTATIVE STANDARD			
Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 27 T)...............	17	0	0

SUBCOMMITTEE ACTIVITIES

Subcommittee II on Structural Lime (N. G. Hough, chairman). —This subcommittee is now working on the development of tentative specifications for pulverized quicklime, as the present-day construction uses for this product require a specification somewhat different from any of those formerly prepared and adopted by Committee C-7.

This subcommittee is recommending the advancement to standard of a portion of the tentative revision, proposed in 1928, of the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 24). The remaining portion of this tentative revision will be given further study and consideration. In this connection, several members of the subcommittee have announced their intention of conducting further research on the method for determining the plasticity of hydrated limes, with special reference to any variation in this property which might be caused by differences in the method and time of stirring the putty.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 774 (1927); also 1930 Book of A.S.T.M. Tentative Standards, p. 170.

Following a careful study of the Tentative Specifications for Sand for Use in Lime Plaster (C 66 – 27 T), it is recommended that these specifications be revised, as mentioned earlier in this report, and that the specifications as revised be continued as tentative.

Subcommittee III on Lime for the Chemical Industries (D. E. Washburn, chairman).—This subcommittee is giving consideration to the preparation of specifications for lime for the manufacture of glass, and also for the manufacture of calcium arsenate. This group also anticipates making an industrial survey to determine the existence of an actual need for further specifications for lime products in this field.

Subcommittee V on Methods of Test of Lime and Lime Products (L. S. Wells, chairman).—This subcommittee is closely following experimental work being conducted at the U. S. Bureau of Standards relating to a new method for determining the soundness of limes, being particularly adapted to the testing of limes for plastering purposes from the standpoint of pitting and popping. Aside from the apparent reliability of the new method, it is of especial importance in reducing the time necessary for a determination from four days, as required by the present method described in the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 24), to three or four hours. A complete report on this new procedure is expected within the near future.

Subcommittee VIII on Nomenclature and Definitions (E. M. Kenworthey, chairman).—This subcommittee is working on the compilation of a list of all terms and definitions relating to the work of Committee C-7. Special study is being given to the preparation of standard definitions covering the unusual words and phrases used in the committee's specifications, some of which have a reference peculiar only to lime products.

Subcommittee IX on Research Problems (J. R. Withrow, chairman). —Of special interest is the formation of a new Subcommittee IX on Research Problems and the appointment of J. R. Withrow, Professor of Chemical Engineering at Ohio State University as its chairman. Among the many problems suggested for study by this subcommittee, the following are typical: effect of particle size on the physical characteristics of lime such as plasticity, cementing value, size of commercial package, ease of wetting and water-lime ratio. Other suggestions included a study of the use of accelerators combined with fine grinding, the comparative slaking rates of shaft and rotary kiln lime and the effect of aging lime putty.

This report has been submitted to letter ballot of the committee, which consists of 36 members; 22 members returned their ballots, of whom 20 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. C. Berry,
Chairman.

W. V. Brumbaugh,
Secretary.

Editorial Note

In accordance with the recommendation of the committee, the tentative revision of the Standard Specifications for Hydrated Lime for Structural Purposes was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931. The standard in its revised form appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 37.

The proposed revision of the Tentative Specifications for Sand for Use in Lime Plaster was accepted. The specifications in their revised form appear on page 738.

REPORT OF COMMITTEE C-8
ON
REFRACTORIES

Committee C-8 held two meetings during the year: at Atlantic City on October 23, 1930, at the time of the fall meeting of the American Refractories Institute, and in Cleveland on February 23, 1931, in conjunction with the annual meeting of the American Ceramic Society.

Recommendations Affecting Standards and Tentative Standards

The committee recommends for use in testing refractories the modulus of rupture or flexural strength test described in Sections 8 to 12 of the Tentative Methods of Testing Brick (C 67 - 30 T)[1] developed under the jurisdiction of Committee C-3 on Brick. This test involves testing the brick flat on flexible knife edges on a span of 7 in. and would be applicable to all types of refractories.

Proposed Tentative Revision of Standards:

Standard Method of Test for Porosity and Permanent Volume of Changes in Refractory Materials (C 20 - 20).[2]—Water has been found equally as satisfactory as kerosine for determining porosity by the suspension method within the limits of accuracy required, and the use of water introduces other economies in time and simplicity of technique. Accordingly, the following changes are being recommended which substitute water for kerosine, provide for boiling the sample instead of a long immersion under vacuum at room temperature, and furnish data for calculating absorption. The committee recommends that the following changes be published as a tentative revision of the Standard Method C 20 - 20:

Section 5.—Change Paragraphs (*c*), (*d*), (*e*), (*f*), (*g*), and (*h*) from their present form: namely,

(*c*) The test specimens shall be placed in kerosine of known density (δ) under a vacuum of 24 in. for 4 hours at 25° C. and cooled to room temperature while yet immersed.

(*d*) When cool, each test specimen shall be weighed suspended in kerosine at 25° C. to determine its *Suspended Weight* (*S*), in grams.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1033 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 198.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 207.

(*e*) The *Saturated Weight* (W), in grams, of each test specimen shall be obtained immediately after obtaining the suspended weight, by drying lightly with a kerosine-moistened towel to remove the excess kerosine and then weighing in air.

(*f*) The *Exterior Volume* (V), in cubic centimeters, of each test specimen is obtained by subtracting the suspended weight (S) from the saturated weight (W), and dividing by the density (δ) of the kerosine. Thus:

$$V = \frac{W - S}{\delta} \quad \text{(1)}$$

(*g*) The *Actual Volume of Open Pores* (V_1) in cubic centimeters, is obtained by subtracting the dry weight (D) from the saturated weight (W), and dividing by the density (δ) of the kerosine. Thus:

$$V_1 = \frac{W - D}{\delta} \quad \text{(2)}$$

(*h*) The *Apparent Specific Gravity* (T_1) of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights, and multiplying by the density of the kerosine. Thus:

$$T_1 = \frac{D}{D - S}\delta \quad \text{(3)}$$

to read as follows:

(*c*) The test specimens shall be placed in distilled water and boiled for 2 hours and then allowed to cool to room temperature while still immersed in water. During boiling, the test specimens shall not be in contact with the heated bottom of the container.

(*d*) *Weight Suspended in Water.*—Each test specimen shall be weighed while suspended in water to the nearest 0.10 g. to determine its suspended weight, S, in grams.

(*e*) *Saturated Weight.*—The saturated weight, W, in grams of each test specimen shall be obtained immediately after obtaining the suspended weight, S, by blotting lightly with a moistened towel to remove the excess water and then weighing in air to the nearest 0.10 g.

(*f*) *Exterior Volume.*—The exterior volume, V, in cubic centimeters of each test specimen is obtained by subtracting the suspended weight, S, from the saturated weight, W.

(*g*) *Actual Volume of Open Pores.*—The actual volume of open pores, V_1, in cubic centimeters is obtained by subtracting the dry weight, D, from the saturated weight, W.

(*h*) *Apparent Specific Gravity.*—The apparent specific gravity, T_1, of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights as follows:

$$T_1 = \frac{D}{D - S}$$

In the formulas which appear in Paragraphs (*j*) and (*k*) omit the function "δ" for the density of kerosine.

New Paragraph.—Add the following new Paragraph (*l*) to Section 5:

(*l*) *Water Absorption.*—The water absorption, A, in per cent is obtained by dividing the weight of the water absorbed, in grams, by the weight of the dry test specimens in grams and multiplying by 100 as follows:

$$A = \frac{W - D}{D} \times 100$$

Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 28).[1]—A number of changes in this method are proposed which represent recognition in the industry of an extension of the original purpose of the test to include not only fire-clay brick but raw fire-clay and silica cement as well. A cone-temperature conversion scale is also appended to the test to satisfy a demand from technologists for a more ready interpretation of the significance of cones in terms of the standard temperature scales. The committee recommends the following changes for publication as a tentative revision of the Standard Method C 24 – 28:

Title.—Further changes are being contemplated in the title of this test method and it is accordingly recommended that the following revised title recommended last year be continued as tentative:

Standard Method of Test for Determining the Pyrometric Cone Equivalent of Fire Clay and Fire Brick.

Section 1.—Change the scope of this method from its present form: namely,

1. The object of this test is to determine the softening point of fire-clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

to read as follows:

1. This method is intended for determining the pyrometric cone equivalent of fire clay, fire brick, silica cement and ground fire clay by comparison of test cones with standard Orton pyrometric cones under the conditions herein prescribed.

Section 2.—Change the description of the preparation of sample from its present form: namely,

2. A 1-kg. (2-lb.) sample shall be taken by chipping off approximately equal portions from the corners of the brick. These fragments shall be reduced in size by means of rolls or a jaw crusher adjusted to pass a lump 6 mm. ($\frac{1}{4}$ in.) in diameter. They shall be mixed thoroughly, and the amount of material reduced to about 250 g. (0.5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall be ground

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 210.

in a porcelain or agate mortar to pass a No. 60 sieve of the United States Standard Sieve Series. In order to avoid excessive reduction of the fines, they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

to read as follows:

2. (*a*) *Lump Clay or Brick.*—The entire sample of lump clay or brick, in case the amount is small, shall be reduced in size by means of rolls or a jaw crusher to a maximum size of ¼ in. In case the amount is large, a representative sample obtained by approved methods shall be so treated. The sample shall then be mixed thoroughly and the amount reduced to about 250 g. (0.5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall then be ground in an agate, porcelain, or hard steel mortar and the amount reduced again by quartering. The final size of the sample shall be 50 g. and the fineness such that it will pass a No. 65 sieve, the diameter of wire being 0. 183 mm. (0.0072 in.) and the screen openings being 0.208 mm. (0.0082 in.). In order to avoid excessive reduction of fines they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

(*b*) In the case of ground fire clay and silica cements, the sample obtained by approved methods shall be tested as received without grinding or other treatment.

The addition of the following Note after Section 2 is recommended since it is felt necessary to avoid the use of the P. C. E. test on refractory cements containing added fluxes, which is at present a subject of study.

NOTE.—For the purpose of this test, silica cement is understood to be the usual mixture of ground ganister and fire clay with no added fluxes. By ground fire clay is understood the usual mixture of ground raw fire clay, calcined clay, or burnt brick with no added fluxes. Neither includes the materials sold under the name of high-temperature cements.

Section 3 (*a*).—Change the description of the test cones from its present form: namely,

3. (*a*) The sample thus prepared shall be thoroughly mixed and, after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. (3/16 in.) on the sides at the base and 25 mm. (1 in.) high.

to read as follows:

3. (*a*) The dried sample shall be thoroughly mixed and after the addition of sufficient dextrine, glue, gum tragacanth or other alkali-free organic binder and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons 8 mm. (5/16 in.) on the sides at the base and 25 mm. (1 in.) in height.

Appendix.—Add the following cone temperature table as Appendix to these methods:

The temperature corresponding with the end points of those standard Orton pyrometric cones, which are used in connection with refractories, are as follows:

CONE	END POINT DEG. CENT.	END POINT DEG. FAHR.	CONE	END POINT DEG. CENT.	END POINT DEG. FAHR.
No. 15	1435	2615	No. 29	1640	2984
No. 16	1465	2669	No. 30	1650	3002
No. 17	1475	2687	No. 31	1680	3056
No. 18	1490	2714	No. 32	1700	3092
No. 19	1520	2768	No. 33	1745	3173
No. 20	1530	2786	No. 34	1760	3200
No. 23	1580	2876	No. 35	1785	3245
No. 26	1595	2903	No. 36	1810	3290
No. 27	1605	2921	No. 37	1820	3308
No. 28	1615	2939	No. 38	1835	3335

NOTE.—These temperatures, which were determined by Fairchild and Peters[a] for a heating rate of 150° C. per hour for cones Nos. 15 to 20, and of 100° C. per hour for cones Nos. 23 to 38, other conditions being the same as specified, apply satisfactorily for all the conditions of this test method, but do not apply to conditions of the commercial firing and use of refractory materials.

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[a] Fairchild and Peters, "Characteristics of Pyrometric Cones," *Journal*, Am. Ceramic Soc., Vol. 9, No. 11, p. 700, November, 1926.

Proposed Revision of Tentative Standard:

Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (*C 38 – 27 T*).[1]—Recognition of certain limitations of this test has prompted a change in the title and scope as well as a minor revision in the manner of measuring the spalling loss. The committee recommends that this method be revised as follows and continued as tentative:

Title.—Change the title by inserting the word "control" between the words "of test."

Section 1.—In order that the scope of this test will conform to the new title, change this section from its present form: namely,

1. The object of this test is to determine the resistance of high-duty fire-clay brick to spalling action, by subjecting them to repeated rapid temperature changes.

to read as follows:

1. This method of control test is intended for determining the comparative resistance of high-duty fire-clay brick to spalling action by subjecting them to repeated rapid temperature changes. It is not to be used as a suitability test, as experience has shown that results obtained in this control test are not comparable with results obtained in service on the same brand of brick. This test is of value, however,

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 837 (1927); also 1930 Book of A.S.T.M. Tentative Standards, p. 202.

as a control test in maintaining the uniformity of fire-clay brick in so far as thermal spalling is concerned.

Section 3 (b).—Change the method of measuring loss described in this paragraph to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

> (*b*) When pieces begin to fall off, the sample [is] *shall be* laid on a 4.5 by 9.0-in. asbestos board divided into [one hundred] *50* equal squares and the approximate percentage of loss estimated after each removal from the water. After the completion of the test, the brick [is] *shall* again *be* weighed and the percentage of loss determined.

Proposed Advancement of Tentative Standard to Standard:

Tentative Definitions of Terms Relating to Refractories (C 71 – 30 T).[1] —The committee recommends that the terms "spalling" and "pyrometric cone equivalent" be advanced to standard and incorporated in the present Standard Definitions of Terms Relating to Refractories (C 71 – 28).[2]

Advancement to Standard of Tentative Revision of Standard:

Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 28).[3]—The committee recommends the advancement to standard of the tentative revision proposed in 1929 in Section 5 (*a*) of this method which covered a change in the time of heating rate requirements for cones Nos. 31 to 35.[4]

The recommendations appearing in this report affecting standards and tentative standards have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARD			
Tentative Method of Testing Brick for Flexure (Modulus of Rupture) (C 67 – 28 T)	26	4	2
II. TENTATIVE REVISION OF STANDARD			
Standard Method of Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 20)	31	0	1
Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 28)	27	3	2
III. PROPOSED REVISION OF TENTATIVE STANDARD			
Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action (C 38 – 27 T)	31	2	1
IV. ADVANCEMENT OF TENTATIVE STANDARD TO STANDARD			
Tentative Definitions of Terms Relating to Refractories (C 71 – 30 T)	33	0	1
V. ADVANCEMENT TO STANDARD OF TENTATIVE REVISION OF STANDARD			
Standard Method of Test for Softening Point of Fire-Clay Brick (C 24 – 28)	32	0	0

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1037 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 204.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 226.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 210.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 282 (1929).

RESEARCH ACTIVITIES OF SUBCOMMITTEES

Additional Standard Samples of Refractory Materials.—By arrangement with the U. S. Bureau of Standards, three new additional samples of magnesite, chrome and silica are being prepared. The addition of these samples will make available a complete line of the best known refractories now in common usage. The committee has felt that a real need exists for these materials and particularly the first two, since because of their expensive nature both the raw materials and finished refractories are very frequently purchased on specifications covering their chemical composition. Batch mixes during production are made up on the same basis necessitating chemical control. Standard samples of the materials will, accordingly, prove of considerable value to both customers and manufacturers of these products, in providing suitable standards against which may be checked the analytical methods in use. The following group of representative producers, consumers and consultants of particular experience in analyzing these materials is cooperating in establishing the compositions:

American Refractories Institute Fellowship
Booth, Garrett and Blair
Carnegie Steel Co.
General Refractories Co.
Harbison-Walker Refractories Co.
Koppers Research Corp.
E. J. Lavino and Co.
Ledoux and Co.
Andrew S. McCreath and Son
The Solvay Process Co.
Mr. M. H. Thornberry, Missouri School of Mines
Northwest Magnesite Co.
Sierra Magnesite Co.

Abrasion at High Temperature.—The study of this problem has been continued at Pennsylvania State College under the supervision of Mr. J. B. Shaw. The original apparatus was rebuilt during the past year and the list of refractories for test was extended to include silica brick. Attempts to develop a simpler apparatus than the original reciprocating chisel resulted in the development of a water-cooled drill which rotates at a point on one face of a refractory as contrasted to the chisel of the first device which moves over the faces of a number of heated brick. The new test appears more satisfactory for differentiating the abrasive resistance of cold brick, but is not as satisfactory as the old test for hot brick. Comparative tests were made with the two aforementioned pieces of apparatus as well as by the rattler method described in the 1929 report[1] of the committee, and by the sand-blast test described in the 1928 report.[2] Data have been developed showing the relation between abrasion loss *versus* absorption, cold crushing strength, P. C. E. value, and grain size of the brick.

Since some question has arisen as to the ultimate principle involved when using the reciprocating chisel, namely, whether the apparatus measures true abrasion or gouging, an analysis of the principles involved was made by Mr. A. E. R. Westman, one of the members of the committee. He concludes that the chisel method has all the elements of ideal abrasion and some of the elements of impact and the test therefore measures real abrasion. Such impacts as do occur are small, are distributed over the test surface of the brick, are at an angle to the test surface of the brick and so simulate abrasion. If such a distributed impact test as the sand-blast test on glazes is to be called an abrasion test, then in general the chisel method may be conceived as measuring abrasive resistance.

Investigation of the P.C.E. Test.—This test again has been the subject of a very critical study by the Section on Temperature under Mr. M. E. Holmes. In connection with the original objective of the section, namely, studying the performance of certain types of furnaces used in making the P.C.E. test with the ultimate idea of making recommendations for a standard furnace, it has been found that there appears a necessity for still further testing work, preferably on the three existant types of furnaces by one laboratory. This conclusion is based on an investigation conducted this past year by Mr. Holmes in which six different laboratories participated, using two electric gran-annular, two gas, and two oxy-acetylene furnaces. Four different refractory materials were studied with the idea of determining which type of furnace furnished most consistent data. An attempt was made to keep all testing conditions uniform in the different laboratories in so far as preparation of the test specimens and heating rate were concerned. In contradiction to the findings of a preliminary investigation of a somewhat similar nature last year, when the electric furnace appeared most consistent, this newer investigation favored the gas furnace.

It has been determined from some further investigative work of the section that the size of the cone is of considerable importance in explaining some of the variations in values shown by the P.C.E. test. The original size of cone recommended in the test has been $\frac{3}{16}$ in. on the side of the base, whereas the Orton cones used as standards average closer to $\frac{5}{16}$ in. Some laboratories, it was found, made their test cones to approximate the Orton cones in size and some confined themselves the $\frac{3}{16}$-in. size. The smaller size gives lower values. The recommendation brought out this year is, accordingly, for the $\frac{5}{16}$-in. cone. Since the investigation has disclosed that the size of both test and standard cones must be maintained uniform, the cooperation of the maker of the standard cones has been solicited to aid the committee in reducing the variables which cause discrepancies in P.C.E. values.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 288 (1929).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 337 (1928).

Two other research projects affecting the usability of the P.C.E. test are in progress as the subject of student theses at the Missouri School of Mines under Mr. Holmes' direction. These are (*a*) the effect of added fluxes frequently present in high-temperature cements and (*b*) the proper determination of values for materials below cone No. 20.

Survey of Furnaces Used to Perform the Load Test.—Rather radical differences sometimes obtained by different laboratories when performing the load test at elevated temperatures have focused the attention of the committee on a study of the causes of these variances. A preliminary survey has just been completed as the first step in this study, giving data on the various furnaces in use and their operating conditions. Information was obtained from thirteen laboratories and covers practically all the outstanding installations of this type of apparatus. Nine furnaces were reported as complying with the standard furnace, four were not, and one was a compromise. Nine operate entirely on gas for fuel, one on oil, and four reported using both kinds of fuel. Thermocouples supplemented with optical pyrometers are in use with most of the furnaces. The number of specimens tested varied from one to ten. However, most laboratories test only two brick. Most of the differences found were in the shape of the furnace, location of the burners, and number of brick tested.

Data are now being collected to determine the causes for the departures found from the standard furnace. It has been suggested that possible lack of uniformity with respect to furnace temperature measurement, design, atmosphere and pressure may explain the variations found.

Microstructure.—In view of the growing usage of petrographic methods in the examination of refractory materials, a new section has been instituted under the direction of Mr. T. A. Klinefelter of the U. S. Bureau of Standards Station at Ohio State University. The choice of Mr. Klinefelter to head this section, will effect a liaison with the important petrographic work being done under his supervision on the reactions of boiler furnace slags on fire-clay refractories, a phase of a general investigation of this subject being carried on by the American Society of Mechanical Engineers. It is felt that as an outgrowth of the technique developed in this special problem, a standard procedure for the study of slags in general on all other type of refractories may eventually be developed.

Measuring Heat Transmission of Refractories.—The construction of a calorimeter for testing refractory insulation has been in progress during the year in the laboratories of a prominent manufacturer of this type of material. This apparatus will be used in determining the proper method for determining heat transmission. In addition, Mr. R. H. Heilman, chairman of the Section on Heat Transmission, has done considerable work at Mellon Institute on the determination of thermal conductivity from temperature measurements of the surface of materials and the outer surface transfer law. The latter has been developed fairly accurately at Mellon Institute and seems to be very applicable to the determination of the thermal conductivity of insulating and refractory materials under actual service conditions.

This report has been submitted to letter ballot of the committee, which consists of 35 members; 34 members returned their ballots, all of whom voted affirmatively.

Respectfully submitted on behalf of the committee,

G. A. BOLE,
Chairman.

L. J. TROSTEL,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Test for Porosity and Permanent Volume Changes in Refractory Materials and Test for Softening Point of Fire-Clay Brick were accepted for publication as tentative and appear on pages 1054 and 1056, respectively.

The proposed revision of the Tentative Method of Test for Resistance of Fire-Clay Brick to Thermal Spalling Action was accepted. The method in its revised form appears on page 777.

The definitions of the terms "spalling" and "pyrometric cone equivalent" appearing in the Tentative Definitions of Terms Relating to Refractories were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931, and appear in the 1931 Supplement to Book of A.S.T.M. Standards, page 72.

In accordance with the recommendation of the committee, the tentative revision of the Standard Method of Test for Softening Point of Fire-Clay Brick was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931. The standard in its revised form appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 69.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES

Committee C-9 on Concrete and Concrete Aggregates held two meetings during the year, both of which were two-day sessions, the first day being devoted to subcommittee meetings, followed by an all-day meeting of the main committee. These meetings were held in Pittsburgh, Pa. on November 13 and 14, and again in Pittsburgh on March 17 and 18 in connection with the Spring Group Meeting of A.S.T.M. committees. Both were well attended and indicated a lively interest in the work. A third meeting is to be held during the annual meeting of the Society just previous to the presentation of this report.

The committee presents herein the results of its year's work on a number of important problems, some of which have been receiving careful attention for several years past but have not until now reached the stage of completeness which would permit the results being published. The work accomplished includes several revisions of existing standards, several new specifications and methods of test offered as tentative and a number of reports on matters relating to tests and test methods.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations affecting standards and tentative standards are noted in brief form below together with the results of the letter ballot. These matters and other activities of the committee are explained in greater detail under the activities of the subcommittees under whose guidance they were prepared.

I. *Proposed Tentative Standards.*—The committee submits for publication as tentative the following five new specifications and three methods of test as appended hereto:[1]

Proposed Tentative Specifications for Curing Portland-Cement Concrete, recommended by Subcommittee XIII:

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[1] See pp. 756 to 768.—Ed.

Proposed Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings, recommended by Subcommittee XIII;

Proposed Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture, recommended by Subcommittee XIII;

Proposed Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride, recommended by Subcommittee XIII;

Proposed Tentative Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings, recommended by Subcommittee XIII;

Proposed Tentative Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar, recommended by Subcommittee IX;

Proposed Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition, recommended by Subcommittee IX;

Proposed Tentative Method of Routine-Analysis of the Cement Content of Hardened Portland-Cement Concrete, recommended by Subcommittee XII.

II. *Proposed Revision of Standard.*—The committee recommends for immediate adoption the following revision in Section 6 of the Standard Method of Securing Specimens of Hardened Concrete from the Structure (C 42 – 27)[1] and accordingly asks for the necessary nine-tenths vote for immediate adoption:

Section 6.—Change this section from its present form: namely,

> 6. *Ends of Test Specimens.*—The specimen secured shall have ends, or beds, as nearly as possible perpendicular to its axis, and, if the specimen has ends with uneven surfaces, these ends shall be made to parallel plane surfaces by capping with a thin layer of mortar richer than the mortar of the specimen or with a mixture of cement and calcined gypsum (plaster of Paris).

to read as follows:

> 6. *Ends of Test Specimens.*—The specimen secured shall have ends or beds as nearly as possible perpendicular to its axis. Before testing, the ends shall be either ground or capped in such a manner that the ends are plane and perpendicular to the axis of the specimen. The material used for capping and the thickness of the cap shall be such that it will not flow or fracture under the load.

III. *Proposed Revision of Tentative Standard.*—The committee recommends that the Tentative Specifications for Concrete Aggregates

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 149.

(C 33 – 30 T)[1] be revised and continued as tentative. The proposed revised specifications are appended hereto[2] and the revisions are described under Subcommittee IX.

IV. *Advancement to Standard of Tentative Revision of Standard.*—The committee recommends that the tentative revision[3] in Sections 4, 6, 7, and 8 of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 – 27)[4] be advanced to standard with the following change in the new Paragraph (*b*) of Section 6:

Section 6 (*b*).—Change the last sentence of the new Paragraph (*b*) to read as follows by the addition of the italicized words:

> The material used for capping and the thickness of the cap shall be such that it will not flow *or fracture* under the load.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Tentative Specifications for Curing Portland-Cement Concrete	38	2	4
Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings	37	3	4
Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture	30	8	6
Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride	34	5	5
Tentative Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings	40	0	4
Tentative Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar	39	3	2
Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition	40	3	1
Tentative Method of Routine-Analysis of the Cement Content of Hardened Portland-Cement Concrete	36	1	7
II. REVISION OF STANDARD			
Standard Method of Securing Specimens of Hardened Concrete from the Structure (C 42 – 27), immediate adoption	41	2	2
III. REVISION OF TENTATIVE STANDARD			
Tentative Specifications for Concrete Aggregates (C 33 – 30 T)	38	4	2
IV. ADVANCEMENT TO STANDARD OF TENTATIVE REVISION OF STANDARD			
Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 – 27)	40	1	3

ACTIVITIES OF SUBCOMMITTEES

Subcommittees I and II—Advisory and Technical (Cloyd M. Chapman, chairman).—In matters relating to the organization and management of the committee's activities, there have arisen a number of problems which have demanded and received much thought and discussion. The committee has revised the method of conducting its regular meetings by requiring reports of subcommittees which are to be acted upon to be in the hands of the Secretary in written form ten days prior to the meeting. This will enable them to be circulated to the entire committee before formal action is taken on them. Such reports must cover the following:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1022 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 176.

[2] See p. 750.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1276 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 788.

[4] 1930 Book of A.S.T.M. Standards, Part II, p. 139.

1. Final reports on finished projects;
2. Progress reports on incompleted projects to be presented only when the work is far enough advanced to contain information of value;
3. List of projects on which work has been done but no report made; and
4. List of projects on which no work has been done.

The new procedure was adopted at the spring meeting and has not as yet had a thorough tryout, but it is expected that it will materially expedite the work in the committee meetings.

Another matter of importance initiated during the past year relates to the preparation of material for a Symposium on the Significance of Various Tests in Judging the Quality of Concrete. The following assignments have been made to members of the committee to prepare sections of the Symposium:

Compressive Strength	D. A. Abrams
Transverse Strength	R. W. Crum
Field Compression Tests	R. B. Young
Modulus of Elasticity	F. E. Richart
Density	A. N. Talbot
Uniformity	R. L. Bertin
Absorption and Permeability	F. R. McMillan
Volume Changes	R. E. Davis
Coarse Aggregate Tests	A. T. Goldbeck
Fine Aggregate Tests	F. H. Jackson

It is expected that this material will be ready for presentation at the 1932 Annual Meeting of the Society.

This committee has made a few changes in its personnel during the past year, due to resignations, but has maintained its limit of 60 active members, a policy which seems to be bearing fruit. One new subcommittee has been organized, namely, Subcommittee XVIII on Ready-Mixed Concrete under the chairmanship of R. B. Young, who resigned from the chairmanship of Subcommittee VI on Design of Concrete. Subcommittee VI is now under the chairmanship of Bert Myers.

Subcommittee III on Unification of Specifications (W. A. Slater, chairman).—The subcommittee has prepared proposed general specifications for concrete, but these have not been given sufficient consideration to permit of their presentation at this time. The specifications are intended to include only the framework necessary to cover the specifications for materials and methods which have been or will be prepared by Committee C-9. The work of this subcommittee is of special value in pointing out phases of problems on which more definite information is required.

Subcommittee VI on Design of Concrete (Bert Myers, chairman).—Due to certain changes in personnel of this subcommittee, which have been mentioned previously, its work has not advanced sufficiently to permit of presenting a report at this meeting. The subcommittee has paid particular attention to the development of a method for design of concrete based on flexural strength. Information has been collected on the effects on flexural strength of such factors as moisture content of specimens at time of test, richness of mix, age of concrete, and surface of aggregate. The subcommittee also has before it the problems of designing concrete by mortar voids, methods for securing high-early-strength concrete and preparation of a specification for proportioning.

Subcommittee VII on Strength Tests of Concrete (A. T. Goldbeck, chairman).—The question has frequently been raised as to the desirability or advisability of raising the standard temperature of moist rooms for storing concrete specimens from 70° F. to 80° F., in view of the difficulty of maintaining a temperature of 70° F. in hot climates during the summer. Mr. D. D. McGuire handled this investigation and sent questionnaires to 20 cement companies, 8 commercial laboratories, and 26 highway departments. As the result of the replies received, and after careful consideration, the subcommittee recommended that no change in the temperature of the moist room be suggested at this time.

The subcommittee is recommending that the tentative revision of Sections 4, 6, 7, and 8 of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field (C 31 – 27), proposed in 1929 and which was slightly revised last year, be advanced to standard with a revision in the new Paragraph (*b*) of Section 6 as mentioned earlier in the report.

The subcommittee has given consideration to desirable revisions in the Standard Methods of Securing Specimens of Hardened Concrete from the Structure (C 42 – 27) and has recognized the inadequacy of the present Section 6 of these methods. A new wording for

Section 6 is accordingly being recommended as mentioned earlier in the report.

The reason for considering the above changes in these two standards is to permit the use of capping materials which have recently been found very convenient and satisfactory, such as mixtures of sulfur with inert material described by P. J. Freeman in Appendix II of the 1930 report of Committee C-9.[1]

Subcommittee VIII on Permeability Tests of Concrete (C. H. Scholer, chairman).—This subcommittee is comparatively new and is just now getting its work well under way. It has prepared a bibliography of the literature and has in preparation a résumé of the data covered by it. Preliminary reports on the results of certain investigations being sponsored by the subcommittee have been presented to the committee, but these are not yet ready for presentation to the Society.

Subcommittee IX on Specifications and Tests of Aggregates (H. F. Clemmer, chairman).—A new proposed Tentative Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar is recommended for publication as tentative as appended hereto.[2] A new proposed Tentative Method of Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition is also recommended for publication as tentative as appended hereto.[3]

The subcommittee is recommending a revision of the Tentative Specifications for Concrete Aggregates (C 33 – 30 T). The revisions include various changes in the wording of specifications for fine and coarse aggregates, the inclusion of a clause on uniformity, a statement of sizes and percentages as to gradation, and a requirement for the use of the water-cement ratio strength test. It was believed more satisfactory to submit these specifications in the revised form for consideration and the revisions have accordingly been incorporated in the specifications as appended hereto.[4]

Subcommittee XI on Apparatus for Testing (D. A. Abrams, chairman).—This subcommittee recommends as an editorial change the addition of the following footnote to Section 2 on apparatus of the Standard Method of Decantation Test for Sand and Other Fine Aggregates (D 136 – 28):[5]

> A pan satisfying these requirements and which may be readily procured in hardware stores everywhere is known as Nesco Royal Granite Enameled Ware, Stew Pan No. 24.

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[1] P. J. Freeman, "Method of Capping Concrete Cylinders Using Sulfur Compound," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 518 (1930).

[2] See p. 767.—Ed.

[3] See p. 766.—Ed.

[4] See p. 750.—Ed.

[5] 1930 Book of A.S.T.M. Standards, Part II, p. 618.

A report on "Pavement Core-Drilling Practice," prepared by L. W. Teller and P. J. Freeman gives results of an investigation of this subject as a part of the activities of this subcommittee and appears as Appendix III to this report.

Subcommittee XII on Measurement of Materials, Mixing and Placing Concrete (R. L. Bertin, chairman).—A study of the question of analyzing fresh concrete has been conducted and is reported in a paper entitled "A Study of the Analysis of Fresh Concrete" by W. M. Dunagan, which appears as Appendix IV to this report. As the result of these studies and much experimentation with various methods and procedures, a proposed Method of Test for the Field Determination of the Constituents of Fresh Concrete is published as information in Appendix V.

Careful consideration has been given by this subcommittee to the method of determining the cement content of set concrete by chemical methods of analysis, proposed by H. F. Kriege, and after some slight changes and the addition of suitable limitations, the proposed Tentative Method of Routine Analysis of the Cement Content of Hardened Portland-Cement Concrete is recommended for publication as tentative as appended hereto.[1] Considerable supporting data and comments concerning this method of test appear as Appendix VI to this report.

Subcommittee XIII on Curing Concrete (R. W. Crum, chairman). —Mr. Crum prepared a general report on curing, which is appended hereto; a Digest of Available Information on the Use of Calcium Chloride for Curing Concrete by H. S. Mattimore and H. Hershey Miller appears as Appendix I; and a Digest on Effect of Curing Methods on the Strength of Concrete by F. C. Lang, is given in Appendix II to the report of Subcommittee XIII. This subcommittee has also prepared the following five proposed tentative specifications for curing concrete which are recommended for publication as tentative as appended hereto:[2]

Tentative Specifications for Curing Portland-Cement Concrete;

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings;

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium-Chloride Admixture;

Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride; and

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings.

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[1] See p. 763.—ED.

[2] See pp. 756 to 762.—ED.

Subcommittee XVI on Elastic Properties of Concrete (F. E. Richart, chairman).—This subcommittee offers a report prepared by P. M. Noble, entitled "The Effect of Aggregate and other Variables on the Elastic Properties of Concrete," which gives some interesting comparisons of mid-western aggregates and also a description of the apparatus used. This report appears as Appendix VII.

Subcommittee XVII on Conditions Affecting Durability (Ephrem Viens, chairman).—This subcommittee has prepared, through F. R. McMillan, a Suggested Terminology Applying to the Study of Concrete Structures in Service, which appears as Appendix VIII.

Committee C-9 has a large and varied program ahead of it and is making gratifying progress along many lines. Much of its effort during the coming year will be directed toward rendering the greatest possible amount of assistance to the Joint Committee on Concrete and Reinforced Concrete in all matters within the scope of this committee.

This report has been submitted to letter ballot of the committee, which consists of 57 members; 44 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

STANTON WALKER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Curing Portland-Cement Concrete, for Curing Portland-Cement Concrete Slabs with Bituminous Coverings, for Curing Portland-Cement Concrete Slabs with Calcium-Chloride Admixture, for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride, for Curing Portland-Cement Concrete Slabs with Wet Coverings, and Tentative Methods of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement-Ratio Mortar, Test for Apparent Specific Gravity of Coarse Aggregates in a Saturated Condition and Method of Routine Anaylsis of the Cement Content of Hardened Portland-Cement Concrete were accepted for publication as tentative and appear on pages 756, 758, 760, 761, 762, 767, 766 and 763, respectively.

The proposed immediate revision of the Standard Method of Securing Specimens of Hardened Concrete from the Structure, proposed on the floor of the annual meeting as mentioned in the Summary of Proceedings, see p. 45, was approved at the annual meeting by a unanimous vote and was subsequently adopted by letter ballot of the Society on September 1, 1931. The standard in its revised form appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 63.

The proposed revision of the Tentative Specifications for Concrete Aggregates was accepted. The specifications in their revised form appear on page 750.

The tentative revision of the Standard Methods of Making and Storing Compression Test Specimens of Concrete in the Field was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931. The standard in its revised form appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 58.

Subsequent to the annual meeting the committee approved proposed Tentative Methods of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate and Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate for submission to the Society through Committee E-10 on Standards. The methods were accepted for publication as tentative on August 6 by Committee E-10 and appear on pages 769 and 773, respectively.

REPORT OF SUBCOMMITTEE XIII ON CURING OF CONCRETE

CURING OF PORTLAND CEMENT CONCRETE WITH SPECIAL REFERENCE TO CURING OF PAVEMENT SLABS

The curing of concrete consists in setting up the most favorable conditions possible for the chemical and physical changes that take place during the setting and early hardening period.

In the case of pavements it is particularly difficult to control the curing conditions because of the extremely large areas of concrete exposed to the elements. It is generally believed that the most favorable condition for curing concrete consists in surrounding the concrete with warm moist air, so that the concrete is kept wet and there is no possibility of loss of moisture and so that if additional moisture is needed for hydration, it can be secured from the air. In the case of pavements, it being obviously impossible to surround the concrete with moist air, all that has been attempted has been to prevent so far as possible the loss of water from the concrete by evaporation and by absorption into the subgrade. The practice with respect to the latter source of loss can be quickly dismissed. The universal custom at the present time is to wet the subgrade more or less thoroughly just before the concrete is placed. The effectiveness of this practice in preventing loss of water from the concrete is not known with certainty, for this phase of the problem has received little study. It is probable that the results are variable, depending upon the nature and condition of the subgrade material. This report is principally concerned with the methods that have been most extensively used for preventing evaporation from the top surface.

It is very difficult to evaluate the differences in quality of concrete due to different curing conditions, since the principal effect is upon durability and may not become apparent for a long time. The only means used as yet for evaluation of the effectiveness of curing methods are studies of moisture-retention properties, strength, volume changes, and surface condition. Moisture-retention investigations have not reached such a point that this factor can be used as a primary basis for comparing methods. The data summarized in Fig. 1 show that the moisture-retention factor is important as respects strength.

Such knowledge as we have concerning the effectiveness of curing methods is based principally on observations of the effects of curing upon: (1) strength; (2) surface condition and (3) volume changes.

WET EARTH, STRAW OR SIMILAR COVERINGS FOR CURING

The most extensively used method for curing pavement slabs is that of keeping the pavement wet by means of a wet burlap covering before setting, followed by a covering of wet earth, straw, sawdust, hay, etc., for the balance of the curing period. If this material is thick enough and is kept uniformly wet, there is little likelihood of moisture loss from the concrete by evaporation.

This method is generally considered by engineers to be satisfactory and to constitute the most favorable condition yet attained in practice for setting and hardening of concrete pavement slabs. It therefore offers the most available basis for comparison or rating of the other methods and will be so used in the following discussion.

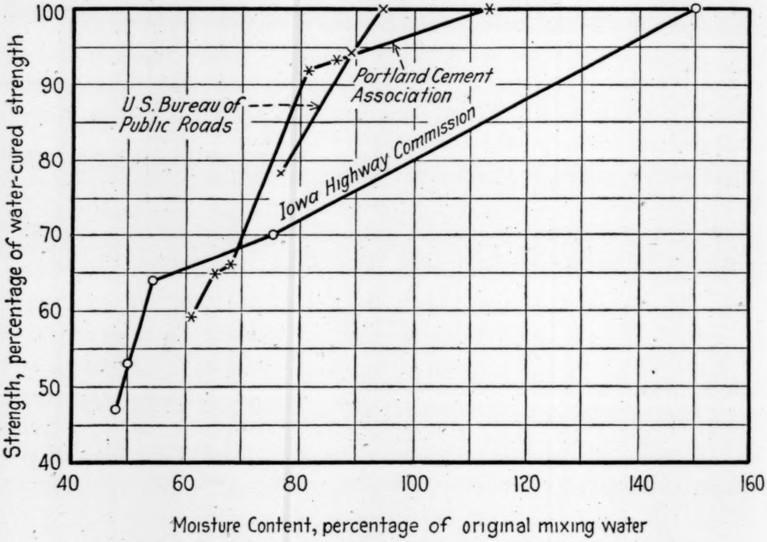

FIG. 1.—Relation of Strength to Amount of Mixing Water Retained.

Iowa Highway Commission: Laboratory tests on 2 by 4-in. mortar cylinders, 1:2 mixtures, age 28 days.

Portland Cement Association: Laboratory tests on 6 by 12-in. concrete cylinders, soaked before testing, age 28 days.

Bureau of Public Roads: Field tests on 6 by 6 by 24-in. beams for strength and 6 by 12 by 24-in. slabs for moisture loss, laid on wet subgrade, age 7 and 21 days.

Although effective if adequately used, the wet coverings have at times some disadvantages. Water may be scarce; covering material may be difficult or impossible to secure; inspection several thousand feet behind the mixer may be lax; and having the concrete buried sometimes interferes with necessary inspection. It was the desire to overcome such disadvantages that brought about the use of other methods. Experience has demonstrated that if used with due regard to their individual limitations and applicability to prevailing conditions, satisfactory results can be secured in various ways.

BITUMINOUS COATINGS

Bituminous coatings are used to seal the exposed surface so that water will not be lost by evaporation. Two types of materials are in use, cut-back asphalts and bituminous emulsions. Each producer has his own specifications for material that will produce the tightly adhering, water impermeable film upon the surface required by the proposed Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings appended hereto.[1] In the present state of knowledge it is not practicable to formulate standard specifications for these bituminous materials.

Mositure Retention.—Most of the information regarding the moisture retaining properties of bituminous coatings has been obtained from tests made on small specimens of concrete molded in open-top pans, beams, or cylinders coated with a film of the bituminous curing material. The loss in moisture was determined by weighing the samples at intervals during the curing period. Most of these tests were made on samples of concrete in pans with enclosed bottoms or on beams kept in the forms during test. The results obtained by several investigators with this type of test show that a bituminous film almost entirely prevents loss of moisture through the surface (**2, 3, 4, 5.**).[2]

This method of testing is not entirely representative of conditions encountered in actual construction, where the top surface of the concrete is coated with bituminous material but the bottom surface is uncoated and in contact with the subgrade. Several tests have been run simulating these conditions. One of these, performed by the U. S. Bureau of Public Roads(**3**), consisted of pouring small slabs of concrete directly on the subgrade soil, coating the top surface with bituminous curing agents, and weighing these slabs at intervals to determine the loss of moisture. The subgrade was thoroughly wet before pouring the concrete slab. The results of these tests showed the bituminous materials to be as effective as wet burlap in preventing mositure loss during the first 24 hours and more effective than any other method except wet earth during the subsequent curing period.

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[1] See p. 758.

[2] The boldface numbers in parentheses refer to the reports and papers given in the list of references appearing on page 346.

Strength and Impermeability.—Since numerous investigators have shown that, provided the inherent properties of the concrete materials are good, the strength, impermeability, and surface hardness of the concrete are dependent on the degree of hydration of the cement, the effectiveness of a curing agent in keeping the concrete moist can be measured by the relative quality of these properties.

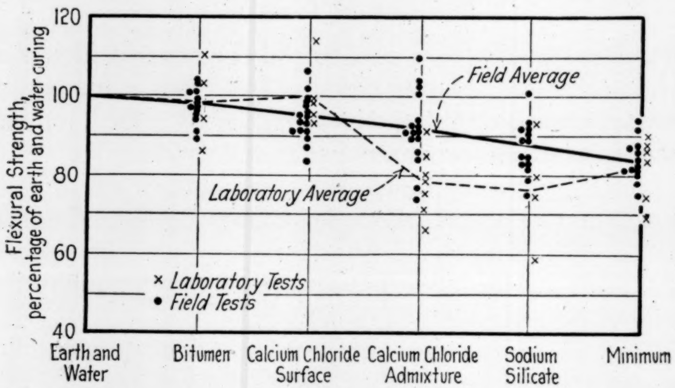

FIG. 2.—Relative Average Flexural Strengths of Concretes Cured by Various Methods.

Each point is the average of the specimens tested on one research project.

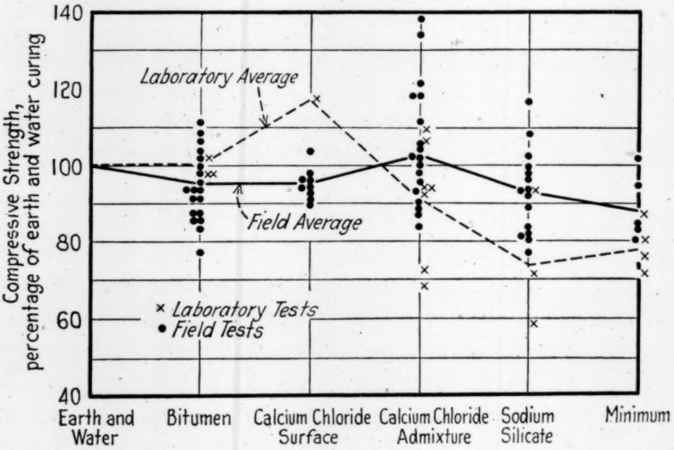

FIG. 3.—Relative Average Compressive Strengths of Concretes Cured by Various Methods.

Each point is the average of the specimens tested on one research project.

A number of laboratory and field investigations have indicated that the bituminous curing method is satisfactory with respect to strength and impermeability when the concrete is cured on the entire external surface(2). Tests have also shown that a pavement poured on a thoroughly wet subgrade and coated on the exposed surface with bituminous materials has satisfactory strength. The test results (see Figs. 2 and 3) show that the strength is generally from 90 to 100 per cent of that obtained in similar pavement cured with wet burlap and wet earth(6).

Surface Hardness and Condition.—No tests extensive enough to warrant specific conclusions have been made on the surface hardness of pavements cured with bituminous materials; however, the fact that a number of pavements so cured have been in active service for a period of four years without entirely losing the bituminous coating indicates that the surface hardness is satisfactory.

No detrimental surface condition, such as scaling, has been reported where bituminous materials have been used as curing agents.

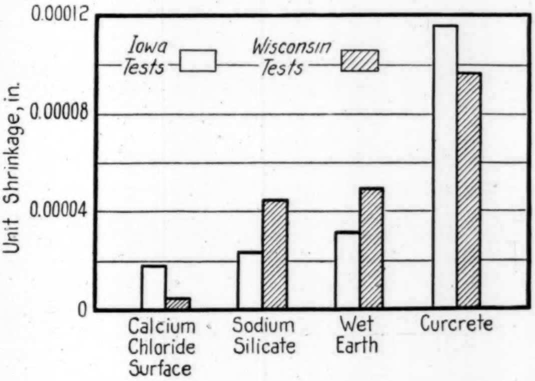

FIG. 4.—Average Maximum Shrinkage During First 96 Hours After Placing. Iowa data acquired by direct measurement; Wisconsin data computed from direct temperature measurements.

Volume Change.—Concrete is a material which changes volume both with changes in temperature and moisture content. This is detrimental in that whenever such volume change is resisted by an external force the concrete is stressed. Inasmuch as bituminous coatings prevent moisture from leaving the concrete through the surface to which they are applied, the use of these materials tends to stabilize the moisture content and hence decreases the volume changes caused by variation in moisture.

However, the volume changes are increased in pavements where the top surface on which the bituminous materials are applied is exposed to the radiant heat of the sun. This is due to the black color of the bituminous material since a black surface absorbs radiant heat from a warmer medium and radiates heat to a cooler medium more readily

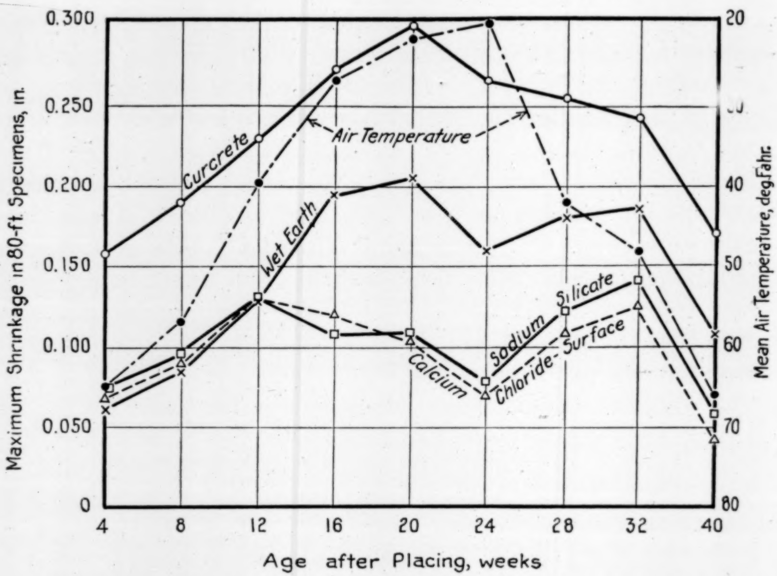

FIG. 5.—Maximum Shrinkage Observed in Slabs 80 ft. long Cured by Different Methods, at Intervals up to 40 Weeks After Construction, with Corresponding Air Temperatures. Data furnished by the Iowa Highway Commission.

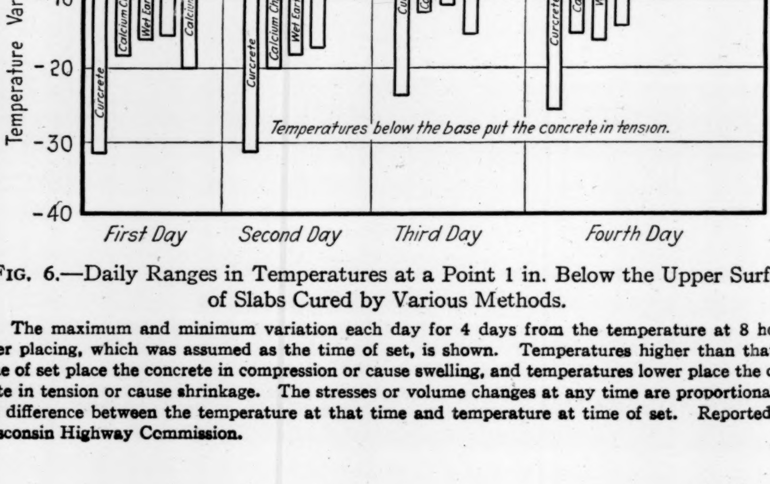

FIG. 6.—Daily Ranges in Temperatures at a Point 1 in. Below the Upper Surface of Slabs Cured by Various Methods.

The maximum and minimum variation each day for 4 days from the temperature at 8 hours after placing, which was assumed as the time of set, is shown. Temperatures higher than that at time of set place the concrete in compression or cause swelling, and temperatures lower place the concrete in tension or cause shrinkage. The stresses or volume changes at any time are proportional to the difference between the temperature at that time and temperature at time of set. Reported by Wisconsin Highway Commission.

than those of other colors. Numerous tests (3, 4, 7, 8) have shown that in cases of bituminous-coated pavements the daily temperature variation has been as high as 50° F. when pavements not so coated had only a variation of 25° F. In the former case the volume change would have been twice as great as in the latter if not resisted by any force. Figures, 4, 5 and 6 illustrate the result of temperature variations on volume changes. In addition to the large daily temperature range at any point in the concrete, bituminous coatings cause a high temperature gradient through the concrete (see Fig. 7). This is because the black upper surface absorbs or radiates heat much more rapidly than it is conducted through the concrete and consequently reaches a much higher or lower temperature than the lower surface. The possible effects upon the pavements of the curling stresses or the warping of the slab, induced by the difference in temperature between the top and bottom, needs further study, as data pertinent to this point are not now available.

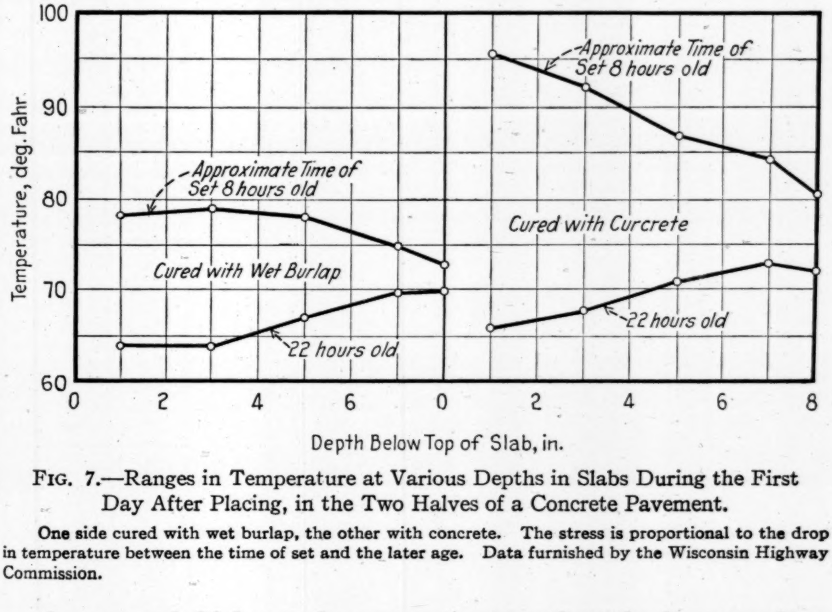

FIG. 7.—Ranges in Temperature at Various Depths in Slabs During the First Day After Placing, in the Two Halves of a Concrete Pavement.

One side cured with wet burlap, the other with concrete. The stress is proportional to the drop in temperature between the time of set and the later age. Data furnished by the Wisconsin Highway Commission.

In pavements, volume change is resisted by subgrade friction and hence the concrete is stressed. This increase in stress in a black colored pavement above that to which a pavement of normal color is subjected usually manifests itself in an increased number of transverse cracks. Surveys on several state highway systems (4, 8) show about twice as many transverse cracks in bituminous-cured pavements as are found in pavements cured by other methods. However, in two states(9, 6) several pavements cured with bituminous materials showed no more cracks than pavements cured by other methods. It was noted that these particular pavements are on fine sandy subgrades having very low frictional resistance to volume change.

Recent experiments(4) indicate that the detrimental effect caused by the dark color of the bituminous materials can be mitigated or entirely relieved by coating the black top with a light colored material immediately after application of the bituminous curing agent. The tests show that the daily temperature range can be decreased by 50 to 60 per cent with a corresponding decrease in volume change; and that up to 180 days, the uncracked slab length can be increased from 50 to 100 per cent by this treatment (see Fig. 8). Test results are not yet available for ages greater than 180 days.

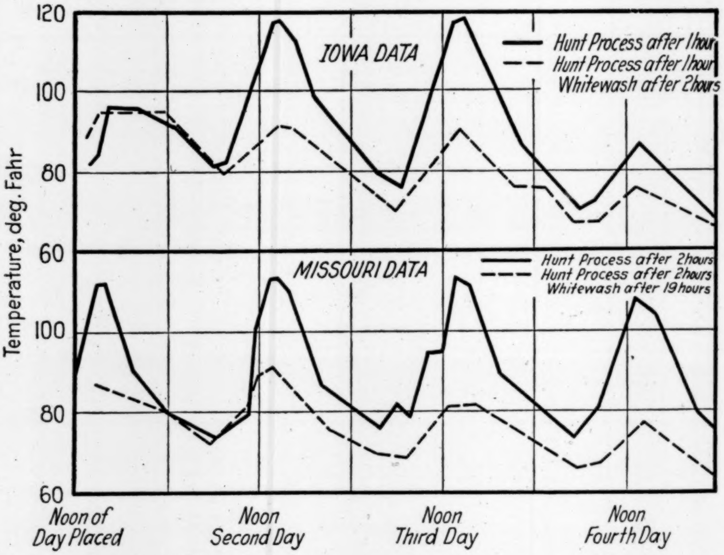

FIG. 8.—Effect of a Coat of Whitewash Applied over a Hunt Process Treatment upon the Temperature of the Top Surfaces of Concrete Slabs.

Further recent tests also indicate that on pavements where crack control is attempted through use of joints at 20 to 40-ft. intervals, depending on the type of aggregate, bituminous curing agents can be used without appreciable increase in the number of transverse cracks(4).

Summarizing the advantages and limitations of curing with bituminous materials the following are set forth:

1. Bituminous curing agents are effective in preventing loss of moisture through the surfaces to which they are applied. As is true with other methods as well, their efficacy as curing agents is dependent, at least to some degree, on prevention of moisture loss through the subgrade.

2. Concrete cured with bituminous materials attains satisfactory strength ranging from 90 to 100 per cent of that attained by water-cured concrete.

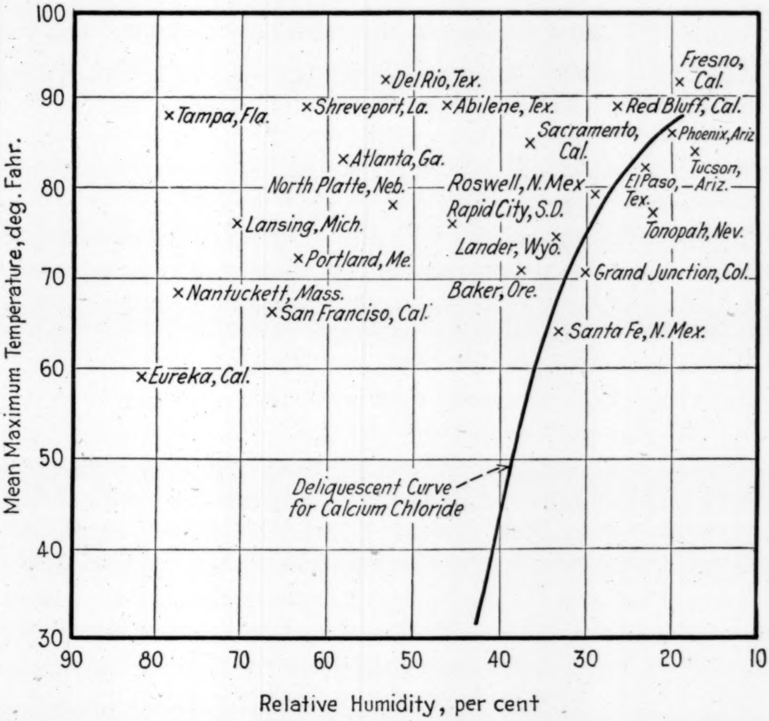

FIG. 9.—Relation of Lowest Relative Humidity and Temperature at Which Calcium Chloride Will Dissolve. It will not dissolve under temperature and humidity conditions to the right of the curve.

The average temperature and humidity for May, June, July, August, and September for several years is shown for a number of localities.

3. Impermeability and surface hardness compare favorably with that of water-cured concrete.

4. The use of bituminous materials in curing concrete exposed to radiant heat causes comparatively large temperature stresses which are manifested by more frequent transverse cracks. These large temperature stresses are objectionable, particularly during the early life of the concrete.

5. Preliminary tests indicate that the temperature stresses can be greatly lessened by coating the bituminous cover in turn with a lighter colored material.

6. Excessive cracking can also be prevented by the proper spacing of transverse joints.

7. Experience with pavements on sandy subgrades indicates that when the friction between slab and subgrade is low, the temperature stresses will not cause excessive cracking.

CALCIUM CHLORIDE, SURFACE APPLICATION

Calcium chloride, being a deliquescent salt, will, under proper conditions, absorb moisture from the air and dissolve, thereby forming on the surface and in the upper pores of the pavement an evaporation resisting film which will protect the concrete beneath from moisture loss. Satisfactory use of this method depends first of all upon the atmospheric conditions. Figure 9 shows the lowest relative humidity at which calcium chloride will dissolve under various temperatures. The U. S. weather reports show that there is a considerable area in the West covering the states of Nevada, Utah, Arizona, New Mexico and parts of California, Oregon, Idaho, Wyoming, Colorado, and Texas where the normal weather conditions are adverse to the deliquescence of calcium chloride. In fact, owing to the scarcity of water and dryness of the air, this region presents a difficult problem in curing concrete pavement by any method.

Strength.—Very little evidence is available concerning the moisture-retention properties of calcium chloride as a surface application. However, data from 14 independent sources(6), comprising 30 experiments summarized in Figs. 2 and 3, show that concrete cured in this manner is 90 per cent or more as strong as wet earth-cured concrete, with no evidence of concrete of inferior quality in this respect. Concrete of satisfactory strength can therefore be expected.

Volume Change.—Volume changes of slabs cured with surface application of calcium chloride are not excessive. They compare favorably in this respect with wet earth-cured slabs. Figure 4, from data furnished by the Iowa Highway Commission(8), and Fig. 5, from Iowa and Wisconsin data(7, 8), show the comparative magnitude of volume changes and temperature variations for the various curing methods. This method appears to be satisfactory on this score.

Surface Condition.—In 1929 the Highway Research Board examined in detail 2043 miles of concrete pavement in Wisconsin, Minnesota, Illinois, Missouri, and Rhode Island to secure data on the amount and causes of surface scaling with special reference to the possible effects of calcium chloride(6). Surface scaling under all conditions was found to be relatively very small in amount. The surface scaling when found was not uniformly distributed over a project, but occurred in widely separated areas. For instance, 0.08 per cent of the total area of 426 miles cured with earth and water, and 0.20 per cent of the area of 1124 miles cured with calcium chloride were scaled. The facts appear to be that scaling is not likely to occur unless stimulated by other conditions than the curing process, but when conditions are such that scaling is likely to occur, the patches of scale will probably be more extensive on the calcium-chloride-cured jobs. However, in view of the very slight prevalence of scale and in view of the fact that reasonable precautions should practically eliminate it altogether, the calcium chloride surface curing method need cause no concern on this account. The phenomenon classed as scale in this report is the typical thin layer of surface that flakes off cleanly from underlying sound concrete. The thickness varies approximately from 0.07 to 0.20 in. The thin surface peel, commonly called "paper scale" is not classed as scale in the report quoted(6); neither is progressive disintegration of the concrete. Figure 10 shows the percentages of scaled area on the pavements arranged according to the years when built.

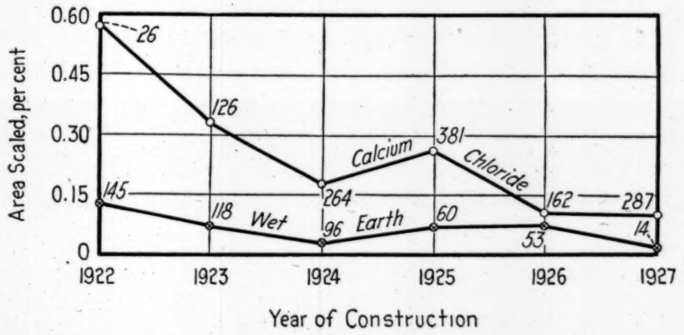

FIG. 10.—Relative Amounts of Scaling on Pavements Cured With Wet Earth and Calcium Chloride Surface Application, by Year of Construction.

Summarizing the advantages and limitation of curing with surface application of calcium chloride it may be said that:

1. Satisfactory strength may be expected;
2. Volume changes are not of importance in comparison with wet earth curing;
3. Satisfactory surface condition may be expected; and
4. For satisfactory use proper atmospheric conditions that will dissolve the calcium chloride must prevail.

CALCIUM CHLORIDE ADMIXTURE

Consideration of integral calcium chloride as a curing process is complicated by the fact that this method depends upon chemical activity, and that the chemical relationships and changes involved are not yet fully understood. The principal function of the salt is to accelerate the setting and hardening of the concrete so that it will be better able to resist stresses at early ages, and so that the curing period may be shortened. In this case a good deal of the curing takes place before the initial wet burlap covering is removed. It is also supposed that the presence of the deliquescent salt resists the evaporation of water from the surface.

Strength.—The fact that the setting and hardening of concrete is accelerated by the admixture of calcium chloride has been well established by numerous investigations. The relative strength of concrete cured in this way to water-cured concrete has not been so thoroughly studied. Figures 2 and 3 show the average results of 50 experiments. It is noticeable that although many of the sets of data show the concrete to be relatively strong as compared to wet curing, in many of the others the concrete was weak by comparison, also a wide range of results was apparent. It is also noticeable that, in general, the good results were secured from tests of specimens made and cured in the field, and that many of the lower results were from laboratory specimens. Figures 2 and 3 show the relationships between laboratory and field tests as revealed in these data. It is probable that the differences are due to differences in rate of loss of mixing water, depending upon temperature, humidity, and air movement. The conditions which make for maximum moisture retention and strength have not yet been defined, although considerable inquiry into these phenomena is under way. Further study is also needed to determine the bases upon which the ratio of calcium chloride to cement should be established to meet varying conditions of temperature and humidity and variations in the different brands of cement.

Volume Change.—Experiments by A. S. Leavens(11) at the University of Minnesota, on volume changes in concrete beams containing an admixture of calcium chloride show appreciable greater shrinkage in such beams than in similar beams not treated with calcium chloride.

The Missouri State Highway Commission(4) has found by surveys of existing pavements and experimental sections of pavements in which calcium chloride was incorporated, that the number of shrinkage cracks is one and one half to two times greater than was found in pavements cured by ponding or surface application of calcium chloride.

Observations of temperature for the first four days at points 1 in. below the upper surface of slabs cured in various ways as reported by the Wisconsin Highway Commission(7) shows daily variations in temperatures that are generally similar for calcium chloride integral, calcium chloride surface, sodium silicate, and wet earth (see Fig. 6).

More data are needed on the effects of calcium chloride on the elastic properties and volume change of concrete in which it is incorporated.

Surface Condition.—In so far as known the surface condition of pavements cured with calcium chloride admixture has been generally satisfactory. The surface condition survey of the Highway Research Board covered 169 miles cured in this way. Some of the projects were practically free from scale while others were somewhat affected. Of 58 miles only 0.015 per cent of the area showed scale and of 112 miles 1.7 per cent showed scale. The difference is attributed to too late finishing in some cases, as the rate of acceleration of setting was greater and the concrete apparently got into an unsatisfactory condition for finishing which caused scaling.

Amount of Calcium Chloride to be Incorporated in the Concrete Mix.—A recent crystallographical study of the setting of mortar having calcium chloride incorporated made by the Ohio State University indicates that the greatest reaction of the calcium chloride is with the tri-silicates and the amount required to obtain the maximum acceleration is therefore affected by the percentage of tri-silicates in the cement.

Strength tests using various proportions of calcium chloride (1 to 2 per cent by weight of the cement) will definitely determine the exact amount to use to obtain maximum acceleration with a particular brand of cement. This percentage ranges from 1½ to 2 by weight of the cement.

The rate of setting of cement in concrete mixtures is accelerated with the rise of the atmospheric temperature, therefore, when concrete is laid during high temperatures the same acceleration will take place with a less amount of calcium chloride than is required during low or normal temperatures. It is, therefore, recommended that when too fast setting occurs for the proper placing of the concrete, the amount of calcium chloride to be added to the mix be reduced until a satisfactory rate of setting occurs, but never to a less amount than 1 per cent by weight of cement.

Corrosion of Reinforcing Steel.—The following data indicate that calcium chloride used as an admixture in concrete does not cause corrosion of reinforcing steel.

A report[1] presented before the American Society for Testing Materials concerning the condition of steel rods imbedded in concrete test specimens containing calcium chloride, for a period of six years states that "The majority of people would pass upon them (steel rods) as being entirely satisfactory. Corrosion is absent over the greater portion of the surfaces of the rods, what rust occurred being localized apparently where voids occurred on the surface of the steel. Comparison of the one year and five year specimens indicate that corrosion is not progressive."

An examination of mesh reinforcing imbedded in concrete pavements in Pennsylvania for at least eight years, in which 2 and 4 per cent, respectfully, of calcium chloride had been used as an admixture, showed the steel to be in first class condition and in as good condition as that in plain concrete.

A recent report of an investigation started five years ago by the Canada Cement Co. states that "Corrosion was found only on the steel imbedded in the dry mixed concrete. None was found in the mortar mixed to 125-per-cent consistency, which is about the usual consistency used in construction of reinforcing concrete. The condition of the steel in both plain and calcium chloride specimens has been found to be almost exactly the same in the specimens examined each year for the past four years. The steel in the majority of specimens examined was found bright and clean."

The presumption that calcium chloride incorporated in a concrete mix may have an effect on the corrosion of steel placed in the concrete is undoubtedly due to the fact that calcium chloride is a salt. However, the steel is not subjected to the effects of calcium chloride as a salt, but rather to the effects of a mass of concrete in which has been included a small percentage of a salt that has been neutralized by the cement, which is a strong alkaline material. Tests show that the addition of calcium chloride, in percentages recommended for use in concrete, does not change the alkalinity of the cement paste, which indicates that its identity as a salt disappears when added to the concrete.

To recapitulate:

1. Calcium chloride used as an admixture will accelerate the setting and hardening of concrete;
2. The strength secured has compared favorably with that of water-cured concrete on many jobs, but the conditions necessary for best results are not entirely understood;
3. Surface condition is satisfactory when properly used.

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[1] *Proceedings* Am. Soc. Testing Mats., Vol. 23, Part II, pp. 327, 328 (1923).

SODIUM SILICATE, SURFACE TREATMENT

It is expected that when sodium silicate applied to the surface of concrete has solidified, a tight, water-impermeable film will be deposited to protect the concrete from evaporation.

Mositure Retention and Strength.—Not much evidence is available as to the moisture-retention properties of the sodium silicate film and what evidence does exist is contradictory. It will be noted on Figs. 2 and 3 that there is a large range in results with this material and that in general, tests of field-cured specimens showed more satisfactory results than did laboratory specimens. From these data it would appear that the laboratory specimens did not retain their water as well as water-cured concrete. This was the case in tests made by the laboratories of the Portland Cement Association(2) and of the Iowa Highway Commission(8). A series of tests intended to more nearly simulate field conditions was recently performed by the Grasselli Chemical Co.(5). Small batches of concrete were poured into bottomless pans 6 in. in depth and placed directly upon a subgrade consisting of sandy loam soil wet down by sprinkling to simulate road conditions. The samples were weighed at intervals to determine moisture loss. In these tests the moisture losses up to 7 days were practically the same for the following methods: (1) Wet burlap for 24 hours followed by application of sodium silicate; (2) Wet burlap for 24 hours followed by surface application of calcium chloride; and (3) Surface coating of cut-back asphalt applied immediately after pouring.

The conditions which will best result in a water-tight film of sodium silicate have not been definite determined.

Surface Condition.—In so far as is known to the committee the surface condition of sodium-silicate-cured roads is satisfactory. Jackson and Bauman(10) report the results of surface wear tests upon variously cured surfaces by means of a machine recently devised by the U. S. Bureau of Public Roads for that purpose, on the Tennessee experimental road. In these tests sodium silicate compares favorably with the other curing methods.

Volume Changes.—As may be expected from the character of the surface, temperature stresses and consequent volume changes have not been found to be materially different for sodium silicate than for wet-earth and the calcium-chloride methods (see Figs. 4 and 5).

In summarizing it may be said that:

1. Satisfactory strength may be expected if a tight film is formed upon the surface. Further study is needed to define all of the conditions under which a satisfactory film will be produced;

2. Volume changes are of the same order of magnitude as in the cases of wet-earth and calcium chloride surface curing; and

3. Surface conditions are satisfactory so far as known.

REFERENCES

(1) *Proceedings*, Ninth Annual Meeting, Highway Research Board, p. 361 (1930).

(2) H. F. Gonnerman, "Study of Methods of Curing Concrete," *Journal*, Am. Concrete Inst., Vol. I, February, 1930, p. 388.

(3) L. W. Teller and H. L. Bosley, "The Arlington Curing Experiments," *Public Roads*, U. S. Bureau of Public Roads, Vol. 10, February, 1930, p. 223.

(4) Unpublished report made to Highway Research Board by Missouri State Highway Dept.

(5) Unpublished report made to Highway Research Board by Grasselli Chemical Co.

(6) Progress Report of Special Committee of Highway Research Board, *Tenth Proceedings*, Highway Research Board.

(7) Unpublished report made to Highway Research Board by Wisconsin State Highway Dept.

(8) Unpublished report made to Highway Research Board by Iowa State Highway Dept.

(9) Unpublished report made to Highway Research Board by California State Highway Dept.

(10) F. H. Jackson and E. W. Bauman, "A Study of Methods of Curing Concrete Pavements," *Public Roads*, U. S. Bureau of Public Roads, January, 1931.

(11) A. S. Leavens, "Tests Show Shrinkage Effect of Calcium Chloride in Concrete," *Engineering News-Record*, Vol. 99, No. 23, December 8, 1927.

Respectfully submitted on behalf of the subcommittee,

R. W. CRUM,
Chairman.

APPENDIX I

DIGEST OF AVAILABLE INFORMATION ON THE USE OF CALCIUM CHLORIDE FOR CURING CONCRETE

By H. S. Mattimore[1] and H. Hershey Miller[2]

As summarized by Subcommittee XIII on Curing of Concrete, in the 1929 Report of Committee C-9,[3] "curing" of concrete means the setting up of favorable conditions for chemical action during the setting and early hardening period; the opinion being that the most favorable conditions exist when the concrete is warm and moist.

(1) D. A. Abrams, "Effect of Time of Mix on Concrete," *Journal*, Am. Concrete Inst., June 29, 1918.

(2) D. A. Abrams, "Effect of Curing Conditions on Strength of Concrete," *Bulletin No. 2*, Structural Material Laboratory.

(3) H. W. Green, "Relation Between Methods of Curing Standard Concrete Test Specimens and Their Compressive Strength at 28 Days," *Proceedings*, Am. Soc. Testing Mats., Vol. XIX, Part II, p. 607 (1919).

Investigators have long recognized that efficient curing is necessary if best results are to be obtained as set forth by Abrams (1, 2) and Green (3), above.

Wet curing is effective but in general it is almost impossible to obtain a continuous, uninterrupted supply of mositure during the full curing period, unless the ponding method can be used.

The need for a method of curing concrete pavements without the use of water has long been recognized by engineers and methods have been advocated that would retain or attract moisture. The calcium chloride methods (surface and integral) are based on the affinity of that salt for moisture, the theory being that it would not only attract moisture but would aid in retaining a part of the water used for mixing to maintain moisture during curing.

This digest, while primarily intended to present the available information on calcium chloride as a curing agent, must of necessity contain references to other methods since most curing experiments are not confined to the action of calcium chloride.

In the following an attempt has been made to review some of the more important curing experiments. The test values usually are given in pounds per square inch and variables in cement strength, proportions, etc., make comparisons difficult. To eliminate these variables all data are presented on a percentage basis so that all tests are on a comparable basis.

(4) H. F. Clemmer and Fred Burggraf, "An Investigation in the Use of Calcium Chloride as a Curing Agent and Accelerator of Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 296 (1923).

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[1] Engineer of Materials, Pennsylvania State Highway Dept., Harrisburg, Pa.

[2] Chief Materials Field Engineer, Pennsylvania State Highway Dept., Harrisburg, Pa.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 303 (1929).

The experiments by Clemmer and Burggraf indicate calcium chloride surface application to be a satisfactory curing method. They state, however, that calcium chloride should not be placed until concrete has hardened, in order that the surface will not be affected. Their experiments include asphalt application which also proved effective. The strength obtained with sodium silicate was about 90 per cent of that obtained with wet earth.

	Modulus of Rupture at 28 Days Strength Ratio	
Method of Curing	Series No. 1	Series No. 2
No curing	97	89
1 lb. per sq. yd. calcium chloride, surface	113	...
3 lb. per sq. yd. calcium chloride, surface	117	...
½–⅔ gal. asphalt	106	...
3 lb. per sq. yd. calcium chloride, after 10 hours.	...	99
3 lb. per sq. yd. calcium chloride, after 24 hours.	...	100
3 lb. per sq. yd. magnesium chloride, calcium chloride, 10 hours	...	94
3 lb. per sq. yd. magnesium chloride, calcium chloride, 24 hours	...	92
Sodium silicate 10 hours	...	86
Sodium silicate 24 hours	...	90

(5) Raymond Harsch, Discussion, "An Investigation in the Use of Calcium Chloride as a Curing Agent and Accelerator of Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 296 (1923).

Experiments by Harsch indicate that the flexural strength of concrete cured with calcium chloride on surface, water-gas tar and coal-gas tar were very much less than wet-sand curing. Compression results, however, show the calcium chloride surface cured concrete to be 93 to 110 per cent of the plain concrete.

	Modulus of Rupture Strength Ratio	
Method of Curing	Large Beams	Small Beams
No curing	64	85
3 lb. per sq. yd. calcium chloride after 3 hours	82	69
3 lb. per sq. yd. calcium chloride after 12 hours. Removed after 24 hours	78	76
2 lb. per sq. yd. calcium chloride after 3 hours	67	87
15 gal. water-gas tar after 24 hours	72	49
2 lb. per sq. yd. calcium chloride after 12 hours. Removed after 24 hours	80	69
15 gal. coal-gas tar after 24 hours	57	66

Method of Curing	Strength Ratios Compressive Strength 6 by 12-in. Cylinders
Wet sand 10 days	100
No curing	96
3 lb. per sq. yd. calcium chloride after 3 hours	110
3 lb. per sq. yd. calcium chloride after 12 hours. Removed after 24 hours	96

METHOD OF CURING	STRENGTH RATIOS COMPRESSIVE STRENGTH 6 BY 12-IN. CYLINDERS
2 lb. per sq. yd. calcium chloride after 13 hours	93
1.5 gal. water-gas tar after 24 hours	56
2 lb. per sq. yd. calcium chloride after 12 hours. Removed after 24 hours	61
1.5 gal. coal-gas tar after 24 hours	54

(6) Report of Committee C-9 on Concrete and Concrete Aggregates, Appendix, Report of Cooperative Series of Tests on Accelerators, Conducted Under the Auspices of Committee C-9, *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 223 (1923).

Nine cooperating agencies show that the addition of calcium chloride to the mixing water accelerates the hardening of concrete at the early ages and shows little or no retrogression up to 1 year with a 2-per-cent solution and a slight gain with a 4-per-cent solution. Due to lack of definite data as to curing, these tests are not included in averages.

Effect of calcium chloride when used integrally on strength of concrete. Nine agencies cooperating. 1:2:4 concrete.

	COMPRESSIVE STRENGTH RATIOS				
	2 DAYS	7 DAYS	28 DAYS	3 MONTHS	1 YEAR
Plain	100	100	100	100	100
Admixture—2 per cent of calcium chloride	164	120	99	95	96
Admixture—4 per cent of calcium chloride	164	124	104	100	103

(7) H. S. Mattimore, Discussion, "An Investigation in the Use of Calcium Chloride as a Curing Agent and Accelerator of Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 315 (1923).

Mattimore, using an admixture of 4 per cent of calcium chloride shows a gain up to and including 1 year.

EFFECT OF CALCIUM CHLORIDE, INTEGRAL

	COMPRESSIVE STRENGTH RATIO					
	3 DAYS	7 DAYS	28 DAYS	3 MONTHS	6 MONTHS	1 YEAR
MORTAR 1:1½						
Plain	100	100	100	100	100	100
Admixture—4 per cent of calcium chloride	116	117	119	111	107	101

CONCRETE 1:1½:3	7 DAYS	10 DAYS	28 DAYS
Admixture—4 per cent of calcium chloride (indoors)	119	104	113
Admixture—4 per cent of calcium chloride (outdoors)	122	121	137

(8) H. F. Gonnerman and C. L. McKesson, "Studies of Curing Concrete in a Semi-Arid Climate," *Bulletin No. 15*, Structural Materials Research Lab., Lewis Inst., and Portland Cement Assn.

It is shown that wet earth is more effective as a curing agent in semi-arid climates than calcium chloride, asphalt paper or sodium silicate. They conclude "deliquescence of calcium chloride takes place very slowly when relative humidity is less than 40 per cent or when the temperature is in excess of 90° F." This would indicate that calcium chloride curing is not effective in semi-arid or arid climates or when average temperatures are more than 90° F.

Comparison of Curing Methods in Semi-Arid Climate

Method of Curing	Strength Ratio Modulus of Rupture 3 Days	7 Days	14 Days	28 Days	90 Days
2 in. wet earth 7/14 day	...	100	100	100	100
2 in. wet earth 3 days	100	98	104	94	94
2½ lb. calcium chloride, surface	...	...	100	88	89
Asphalt paper	...	92	91	88	78
Sodium silicate	...	76	76	74	74
No curing	87	78	78	72	73

(9) D. A. Abrams, "Calcium Chloride as an Admixture in Concrete," *Bulletin No. 13*, Structural Materials Research Lab., Lewis Inst., and Portland Cement Assn.

In a series of experiments with calcium chloride used as an admixture and several commercial preparations (essentially calcium chloride solutions) Abrams found increased strengths up to and including 3 years. These data are not included in averages since various methods of curing not comparable were employed.

Admixture	Strength Ratio, 1:5.2 Concrete 2 Days	7 Days	28 Days	3 Months	1 Year	3 Years
None	100	100	100	100	100	100
Calcium chloride A	170	125	110	112	117	118
Calcium chloride B	147	124	109	109	119	116
Cal	151	123	107	107	121	119
Low-chlorine Cal	143	118	101	104	113	111
Vitriflux	130	115	106	108	109	114

Using concrete mixtures from 1:2 to 1:7 2 per cent of calcium chloride as admixture

Mixture	Strength Ratio to Plain Concrete 2 Days	7 Days	28 Days	3 Months	3 Years
1:7	115	107	85	88	95
1:5.2	138	125	107	110	110
1:4	148	130	119	117	115
1:3	150	130	122	119	115
1:2	149	130	122	120	115

(10) Report of Pennsylvania Department of Highways, Vol. IV (1929).

The Pennsylvania Department of Highways finds that calcium chloride admixture proves efficient as a curing agent when used outdoors but indoors with low humidity and high temperature strengths are less than that of wet burlap cured specimens.

2 per cent of Calcium Chloride as Admixture

Curing	Compressive Strength Ratio 1:2:3 Mix 2 Days	4 Days	7 Days	10 Days	14 Days	28 Days	90 Days
Wet Burlap	100	100	100	100	100	100	100
Calcium chloride, indoors	150	126	120	110	90	90	92
Calcium chloride, outdoors	...	...	100	120	95	95	93

CURING	MODULUS OF RUPTURE STRENGTH RATIO 1:2:3 MIX 2 DAYS	4 DAYS	7 DAYS	10 DAYS	14 DAYS	28 DAYS	90 DAYS
Wet Burlap.....	100	100	100	100	100	100	100
Calcium chloride, indoors.......	125	100	98	98	91	75	88
Calcium chloride, outdoors......	...	...	95	98	99	113	110

(11) R. W. Crum, Progress Report, Iowa Highway Commission (Unpublished).

A series of tests were conducted to determine the effect of calcium chloride on concrete. Seven cements were investigated using 2 per cent of calcium chloride on basis of cement. The modulus of rupture of concrete was equal to plain concrete, the compressive strength was greater. Tests were made at 4, 7, 14, 21, 90 and 180-day periods. No retrogression in flexural strength of concrete containing a 2-per-cent solution of calcium chloride up to 180 days was found and a gain in compressive strength was shown.

(12) L. C. Stewart, "Effect of Calcium Chloride on Transverse Strength of Concrete Cured at Various Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, p. 451 (1926).

An investigation covering the effect of temperatures with and without addition of a 2-per-cent solution of calcium chloride showed increased strength when the solution was used.

CURING TEMPERATURE, DEG. FAHR.	MODULUS STRENGTH RATIO,[a] 1:2:4 MIX 7 DAYS	28 DAYS	3 MONTHS	1 YEAR
15..................................	264	377	144	125
22..................................	99	240	144	155
30..................................	93	95	100	106
70..................................	105	117	108	102

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[a] Compared to plain specimens.

(13) F. H. Jackson, *Public Roads*, U. S. Bureau of Public Roads, Vol. 9, No. 7, September, 1928.

Jackson gives results of an investigation covering use of sodium silicate and calcium chloride and concludes that both appear to act as effective curing agents.

CURING WITH WET EARTH, SODIUM SILICATE, CALCIUM CHLORIDE ADMIXTURE 1:2:4 CONCRETE

CURING	COMPRESSIVE STRENGTH RATIO 1 DAY	3 DAYS	7 DAYS	14 DAYS	21 DAYS	28 DAYS
First Section:						
Wet earth.............	100	100	100	100	100	100
Sodium silicate.........	119	166	103	98	100	97
Calcium chloride.......	178	137	93	99	104	107
	2 DAYS	4 DAYS	8 DAYS	15 DAYS	22 DAYS	29 DAYS
Second Section:						
Wet earth.............	100	100	100	100	100	100
Sodium silicate.........	89	110	91	103	105	101
Calcium chloride.......	260	172	127	118	116[a]	109[b]

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[a] Calcium chloride at 21 days.

[b] Calcium chloride at 28 days.

COMPRESSION TEST ON DRILLED CORES

	Strength Ratios					
		First Section			Second Section	
Curing	28 Days	4 Months	6 Months	1 Year	6 Months	1 Year
Wet earth	100	100	100	100	100	100
Sodium silicate	88	88	95	98	110	107
Calcium chloride	81	85[a]	98	97	101	110

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[a] Calcium chloride at 3 months.

(14) D. G. Runner, Division of Tests, West Virginia State Highway Dept.

Runner compares air, earth, sodium silicate, curcrete and calcium chloride surface curing. The methods all show some merit but air cured specimens seem better in compression and about equal in modulus of rupture. This might be explained by the fact that dry concrete usually shows a gain of 25 per cent over wet specimens in compressive strength.

CURING WITH AIR, EARTH, SODIUM SILICATE, CURCRETE AND CALCIUM CHLORIDE

	Strength Ratio, Age 28 Days	
Curing	Compression	Flexure
Air	122	94
Earth	100	100
Sodium silicate	92	83
Curcrete	97	99
Calcium chloride surface	96	93

(15) Report of Pennsylvania Department of Highways Research, Vol. III (1928).

Age 28 Days

The Pennsylvania Department of Highways comparing calcium chloride admixture, tar and sodium silicate on laboratory cured specimens show sodium silicate and calcium chloride higher in modulus and compressive strength and tar lower than wet straw cured specimens. In field experiments sodium silicate was lower than calcium chloride.

CURING WITH TAR, STRAW, SODIUM SILICATE, AND CALCIUM CHLORIDE ADMIXTURE

	Strength Ratio	
Curing Method	Compression	Flexure
Wet straw	100	100
Calcium chloride, admixture	115	114
Sodium silicate	106	115
Tar	98	86

CURING WITH SODIUM SILICATE AND CALCIUM CHLORIDE ADMIXTURE

	Flexure			Compression on Cores
Curing Method	3 Days	7 Days	10 Days	10 Months
Calcium chloride, admixture	100	100	100	100
Sodium silicate	80	82	85	96

(16) New Jersey Highway Department, Curing Tests, Route 40, Sec. 3 (1930).

New Jersey comparing curcrete, Hunt Process, calcium chloride surface, calcium chloride admixture and sodium silicate shows strength in excess of damp straw for all methods except sodium silicate and this method slightly below damp straw.

1:1.4:3.5 MIX

CURING	1 SERIES—7 DAYS			FIRST SERIES—28 DAYS		
	CYLINDERS	CORES	BEAMS	CYLINDERS	CORES	BEAMS
Curcrete	116	[a]	106	109	102	108
Hunt Process	125	96	103	112	108	127
Calcium chloride, surface	128	[a]	107	120	97	137
Calcium chloride, admixture	135	97	93	114	109	87
Sodium silicate	93	[a]	91	86	89	86
Sodium silicate	112	[a]	91	92	104	87
Damp straw	100	100	100	100	100	100
Damp burlap	97	[a]	88	90	90	84
	SECOND SERIES—7 DAYS			SECOND SERIES—28 DAYS		
Curcrete	119	[a]	100	95	89	88
Hunt Process	112	[a]	92	104	98	101
Calcium chloride, surface	101	[a]	88	106	99	91
Calcium chloride, admixture	107	[a]	69[b]	100	99	96
Sodium silicate	111	[a]	73[b]	118	93	89
Sodium silicate	115	[a]	82	116	88	84
Damp straw	100	[a]	100	100	100	100
Damp burlap	98	[a]	86	122	91	87

	AVERAGE ALL TESTS			GRAND AVERAGE
Curcrete	109	95	100	101
Hunt Process	113	101	106	107
Calcium chloride surface	114	98	106	106
Calcium chloride admixture	114	102	92	103
Sodium silicate	102	91	89	94
Sodium silicate	109	96	87	97
Damp straw	100	100	100	100
Damp burlap	102	90	86	93

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[a] No specimens taken.

[b] Not included in average of all tests.

(17) F. C. Lang and Fred Burggraf, Report of Committee on Curing, *Ninth Proceedings*, Highway Research Board, p. 369.

This report reviews 36 curing investigations and outlines a plan for a comprehensive curing experiment. The laboratory cured specimens show lower strengths in general than field specimens which leads one to believe that when concrete is allowed to cure under low humidity and high temperatures sufficient moisture is not retained or attracted to insure proper curing.

CONCLUSIONS

Summaries of the investigations included in this digest are given in Tables I and II. It appears from a comparison of the data presented that several of the methods outlined have merit as curing mediums. From these tests no curing ranges from 75 per cent to 100 per cent of earth cured with the different alternate methods falling somewhere within or above this range.

In these experiments an attempt was made to provide adequate moisture to specimens cured with earth, straw, etc., while in practice on road slabs much of the pavement is not properly cured.

Calcium Chloride (*Surface Method*).—This method has proved satisfactory as an alternate curing method provided the relative humidity is expected to exceed 50 per cent with normal temperatures. It use should not be advocated in arid or semi-arid regions or under high temperatures. It should not be applied until concrete has hardened to guard against warping or scaling. Green concrete should be protected with wet burlap until ready for application of calcium chloride.

TABLE I.—SUMMARY OF RESULTS OF 36 CURING INVESTIGATIONS.

Values in parentheses are number of projects from which results were secured.

Method of Curing	Average at All Ages up to 1 yr.				28-day Tests			
	Flexure		Compression		Flexure		Compression	
	Field Specimens	Laboratory Specimens	Field Specimens	Laboratory Specimens	Field Specimens	Laboratory Specimens	Field Specimens	Laboratory Specimens
Wet earth or straw	100	100	100	100	100	100	100	100
No Curing	84 (8)	81 (7)	76 (1)	73 (4)	83 (7)	80 (6)	73 (1)	71 (3)
Calcium chloride, surface	97 (9)	102 (4)	93 (4)	....	98 (9)	96 (3)	93 (1)	....
Calcium chloride, admixture	94 (11)	75 (3)	103 (16)	89 (5)	91 (8)	76 (5)	106 (5)	90 (4)
Sodium silicate	87 (9)	79 (4)	96 (11)	79 (4)	87 (9)	78 (4)	92 (2)	77 (4)
Hunt Process	95 (2)	97 (1)	89 (1)	99 (1)	90 (2)	90 (1)	90 (1)	102 (1)
Curcrete	99 (3)	93 (1)	106 (4)	90 (1)	98 (3)	88 (1)	107 (2)	89 (1)
Miscellaneous bitumen	93 (2)	90 (2)	....	98 (1)	93 (2)	90 (2)	....	98 (1)

TABLE II.—SUMMARY OF ALL CURING EXPERIMENTS.

Results at Ages Below 7 Days Not Included.

	Reference to Abstract Number													Number of Projects[d]	Average
	(4)	(5)	(6)[a]	(7)	(8)	(9)[a]	(10)	(11)[b]	(13)	(14)	(15)[c]	(16)	(17)		
Wet curing	100	100	100	100	100	100	100	100	100	100	100	100	100	0	100
No curing	93	82	...	...	75	...	...	...	...	108[a]	...	...	78	24	82
Curcrete	...	...	...	...	...	...	...	...	...	98	...	101	96	11	98
Hunt Process	...	...	...	...	...	...	...	...	...	...	...	107	94	6	100
Asphalt	106	...	...	...	...	...	...	...	...	...	...	...	94	6	100
Sodium silicate	88	...	...	...	75	...	...	...	99	88	110	96	84	31	91
Calcium chloride surface	107	81	...	...	92	...	...	...	...	95	...	106	97	22	96
Calcium chloride admixture	...	...	105	119	...	116	99	108	103	...	115	103	90	45	105
Magnesium chloride—Calcium chloride surface	93	...	...	...	...	...	...	...	...	...	...	...	...	1	93
Cal	...	...	...	...	...	115	...	...	...	...	...	...	...	1	...
Vitriflux	...	...	...	...	...	110	...	...	...	...	...	...	...	1	...
Low chlorine cal	...	...	...	...	...	109	...	...	...	...	...	...	...	1	...
Tar	...	59	...	...	...	...	...	...	...	...	92	...	...	2	76
Asphalt paper	...	...	...	...	87	...	...	...	...	...	...	...	...	1	87

[a] Not included in averages.
[b] Does not include Table No. 17.
[c] Includes tests on concrete at 70° F.
[d] Indicates number of projects on which results for a given method of curing are based.

Calcium Chloride Admixture.—This method has proved satisfactory as an alternate curing method provided the relative humidity is expected to exceed 50 per cent with normal temperatures. Its use should not be advocated in arid or semi-arid regions or under high temperatures. Laboratory investigations generally show lower strengths than wet curing which substantiates the theory that unless sufficient moisture is present in the atmosphere this method would not prove as efficient as wet curing.

The use of calcium chloride as an admixture has the added advantage of acceleration which tends to strengthen the concrete at the earlier periods. This would result in a reduction of curing time. The concrete should be protected for the first 24 hours with saturated burlap; the burlap to be kept in a saturated condition for the full 24 hour period.

SUMMARY

It would appear from the material presented that the calcium chloride methods of curing have been successful. Probably more mileage has been cured with calcium chloride surface and admixture than any other method except wet curing. Both of these methods have their limitations and should be used only under the best conditions of field control.

It is the author's opinion that if any of the alternate curing methods are used it would add to their efficiency by insisting on *wet* curing for a period of 24 to 72 hours, dependent on atmospheric conditions. With the usual wet curing encountered on road construction the alternate methods would at least be as efficient and would offer a possible solution to a vexing problem.

APPENDIX II

DIGEST ON EFFECT OF CURING METHODS ON STRENGTH OF CONCRETE

By F. C. Lang[1]

(1) H. F. Gonnerman, "Study of Methods of Curing Concrete," *Journal*, Am. Concrete Inst., Vol. I, No. 4, February, 1930, p. 359.

This was a very extensive laboratory investigation. About 17 different curing methods grouped under water curing, surface coatings, calcium chloride admixture, and calcium chloride surface covering were used. The specimens were tested for compressive and flexural strength at different ages from three days to one year. Tests were also made for wear, ball indentation, absorption, and moisture losses. From results of strength tests, the author concludes that the coating of silicate of soda and admixture of calcium chloride are not satisfactory curing methods.

(2) S. B. Slack, "Comparative Strength of Concrete Cured by Three Different Methods," *Engineering News-Record*, Vol. 101, p. 170 (1928).

Cooperative curing experiment by U. S. Bureau of Public Roads and State Highway Board of Georgia on section of pavement cured by earth and water, calcium chloride surface and silicate of soda in alternate sections. Total length 50,083 ft. Experiment conducted in 1928. Cores drilled from pavement and results of tests by Bureau of Public Roads and State of Georgia are both given. Earth and water gives highest strength, but the difference between highest and lowest strength reported on either test is about 7 per cent.

(3) "Curing Concrete by Use of Impervious Films of Asphalt and Other Materials," *Proceedings*, Am. Concrete Inst., Vol. XXV, p. 441 (1929).

An investigation of the California Division of Highways' methods of curing by conserving the mixing water under a waterproof film applied to the surface of concrete pavement with a view to eliminating use of earth blankets and water. Tests were made on sections of highway under normal construction conditions. The sections were coated with various materials as were co-related concrete cylinders and slabs cast on the job. The slabs were removed at 10 and 25 days, sawed into beams and broken. Cores were also drilled from the same location in which the cylinders were cast. This study showed that concrete cured by the use of damp earth or by ponding gave greater strength than that cured in any other manner.

(4) "Curing Concrete Pavements," *Journal*, Am. Concrete Inst., Vol. II, No. 5, January, 1931, p. 485.

The purpose of this investigation by the Kentucky State Highway Department and University of Kentucky was to determine whether pavement protected with wet burlap for 24 hours is as satisfactory as that covered on the surface with calcium chloride following the 24-hour wet burlap curing. The concrete used was a 1:2:3.5 mix by volume field condition, with an average cement factor of 1.52. Washed bank sand and gravel of satisfactory gradation were used with standard portland cement averaging about 300 lb. in tensile strength at 7 days. Two 7 by 7 by 30-in. beams were made each day for 20 days; both were covered with wet burlap for the first 24 hours, after which one beam of each pair was surface-treated with calcium chloride. The specimens were tested in flexure and compression at 7, 14, 21, and 28 days. During the construction of the pavement the concrete was covered over with wet burlap for the first 24 hours, after which every alternate 50-ft. section was treated with calcium chloride. Two cores were taken from each treated and untreated section. The results obtained from these tests indicate that there is no advantage in using calcium chloride, since almost equal strengths were obtained for both treated and untreated concrete, and the untreated concrete developed sufficient strength at 7 days both in flexure and compression to permit opening the pavement. A study of cracking of the pavement did not show any advantage of the treated over the untreated concrete.

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[1] Engineer of Tests and Inspection, Minnesota Highway Dept., St. Paul, Minn.

When the project was nearing completion it was found that the supply of calcium chloride was exhausted. It was decided to omit calcium chloride from the last 3000 ft. of pavement, but to treat 2000 ft. of concrete with silicate of soda. The small amount of work done in this connection indicated that there is nothing to be gained by using this material.

(5) "Effect of Different Methods of Curing on Strength of Concrete," Pennsylvania Department of Highways.

This investigation covered a comparison of the value of wet straw, calcium chloride used integrally, and asphaltic emulsion sprayed on the surface as curing agents. Sections of a state highway were cured by these methods. Specimens were molded for strength determinations at various ages, and cores were taken from the road at the six-month and one-year periods. The strength of beams, cylinders, and cores was about equal. At the six-month period the calcium chloride and straw-cured cores gave a strength of 4100 lb. while those cured with the asphaltic emulsion were slightly lower. The beams and cylinders cured with calcium chloride were slightly higher at 7 and 10 days than either of the others, but at the 14 and 28-day periods the strengths were about equal.

(6) "Methods of Curing Concrete," Iowa State Highway Commission.

This problem was concerned particularly with curing of concrete pavement slabs. The investigation was conducted in four groups, each of which consisted of tests on slabs 10 by 10 ft. by 6 in., made in a manner approximating ideal field conditions, and including from four to fifteen methods of curing. In the construction of the slabs longitudinal divider boards were spaced $2\frac{1}{2}$ ft. apart, thus dividing the slabs into four strips $2\frac{1}{2}$ ft. wide and 11 ft. long. These strips were removed one day before testing at ages of 7, 28, 90, and 360 days. Each strip was sawed transversely into 6 by 6 by 30-in. beams on which flexural tests were made. Compression tests were made on specimens prepared from the beams. The results indicate that the wet burlap moist earth method of curing is the most efficient method available; that other methods afford strength results of varying percentages of the results obtained for this method; that asphaltic coatings such as Curcrete and Hunt Process are 90 and 95 per cent as effective as this method; that calcium chloride on the surface is about the same; and that the original water content of the concrete must be maintained or even augmented for the most efficient curing.

APPENDIX III

PAVEMENT CORE-DRILLING PRACTICE

By L. W. Teller[1] and P. J. Freeman[2]

At the November 1930 meeting of Committee C-9, a progress report was presented of the study of the operation of pavement core drills being made by Subcommittee XI on Apparatus for Testing. Since the November meeting the data contained in the progress report have been augmented by information from several additional sources.

Two commercial testing laboratories, two core-drill manufacturers, eleven state highway departments and the U. S. Bureau of Public Roads were asked to contribute information concerning their experience in the core drilling of concrete pavements. These inquiries covered certain specific items and asked for additional comments and suggestions. Replies were received from all but one of the sources solicited and in general these replies were carefully prepared and each contained some bit of information not found in the others. The section of Subcommittee XI wishes to record its appreciation of the courteous consideration given to its requests by the various organizations to which they were addressed.

In the paragraphs which follow the information received will be discussed and summarized.

Spindle Speeds.—It appears that spindle speeds of from 50 to 350 r.p.m. are in current use although the majority of operators use speeds of between 200 and 250 r.p.m. One manufacturer states that after considerable experimentation it was found that a linear speed of the cutting edge of the bit of from 300 to 375 ft. per minute gave the best cutting rate and a uniform core. It is also apparent from the data received that, in general, the same spindle speed is used for all materials. The reason for this is that if the spindle speed is increased for cutting in soft material the steel shot are not kept under the cutting edge of the bit, but are thrown away from it. A few users vary the speed in special cases, such as reducing it when starting the drill in concrete containing especially hard aggregates or when steel reinforcement is encountered. The fact that there is very little range in bit diameters for pavement drilling probably accounts for the lack of data on the most suitable speed for different sizes of bit. The manufacturer who set up the criterion of 300 to 375 lineal feet for a speed of the cutting edge of the bit reported that he found this to hold for bit diameters of from 3 to 18 in.

Spherical versus Crushed Shot.—There is a general preference for spherical shot. Various reasons are given for this, as follows:

1. The wear of the bit is considerably greater when crushed shot (or "grits") are used.
2. A greater quantity of crushed shot is required per core than of spherical shot.

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[2] Chief Engineer, Bureau of Tests and Specifications, Department of Public Works, Allegheny County, Pittsburgh, Pa.

3. The cost per pound of crushed shot is much greater than that of spherical shot.

In addition to these statements, which seem to be generally agreed upon, certain operators report other reasons for preferring spherical shots. However, several operators believe that the crushed material is distinctly helpful in starting the bit and in one state which does a great deal of drilling it is reported that "grits" are used exclusively as it is believed that better cores are obtained. The opinion that smoother core surfaces are obtained when crushed shot are used is expressed by several but most of the operators seem to think that the advantages of spherical shot far outweigh the disadvantages.

Thickness of Bit Wall.—Nearly all of the operators have experimented with variations in the wall thickness of the cutting bits and appear to have reached the same conclusion, which is, that if the wall thickness is too great, an unnecessary amount of material is cut away while if the wall is too thin the shot are not held under the cutting edge and the result is unsatisfactory. Bit thicknesses of not less than ¼ in. and not more than ½ in. are being used by all of the organizations whose reports are included in this survey.

Design of the Cutting End.—Quite a variety of designs of this feature are reported. All operators use a slotted bit and all but two use a single slot. The design of this slot varies from ¾ to 2 in. in width, from 2 to 18 in.in length, and from 0 to 45 deg. in angle of inclination (from the vertical). In general, however, the width is about 1 to 1¼ in., the length from 6 to 12 in. and the angle of inclination 45 deg.

Since the function of this slot is to supply abrasive to the cutting edge it would appear that the slot should be wide enough to prevent clogging; particularly at the cutting edge where a fin is apt to form and should be long enough so that the upper end is at all times above the upper surface of the pavement slab. This will tend to keep the shot from rolling between the side wall of the bit and the core and will feed the shot directly to the cutting edge. Increasing the angle of inclination increases the slot width at the cutting edge without removing additional metal from the slot itself.

Ordinarily these slots are cut with an acetylene torch. One operator welds the ends remaining after the bit has become too short to use, to new bits thus using every inch of bit length.

Another feature employed by some is to use a cast or sheet metal cone within the bit to spread the shot and water to the wall of the bit. This cone is free and is placed on the pavement when the cut is started.

Hard versus Soft Steel Bits.—There is a general preference for soft steel bits. The opinion is prevalent that the soft steel cutting edge soon becomes roughened and this roughness serves to carry the shot along with the bit. In general, the bits are made of steel pipe. One operator prefers wrought-iron pipe and another cast-iron pipe. The latter was old cast-iron water pipe which was available at a very low cost. The former was selected after experiments which led to the conclusion that the wrought-iron pipe (of medium hardness) was better and cheaper than steel pipe.

Pressure on Drill Spindle.—There is a lack of definite data on this item. It is the general opinion that this pressure must be varied with different materials for most effective operation and that judgment regarding this pressure is essential if smooth cores are to be obtained.

The pressure will also vary with the spindle speed, being less for the higher speeds than for the lower.

In general, it appears that a spindle pressure of about 50 or 60 lb. per in. of core diameter gives satisfactory operation.

Addition of Other Abrasives (*Sand, etc.*).—Nearly all of the operators have experimented with the use of sand as an added abrasive and appear to have reached the conclusion that sand does not assist but rather retards the cutting rate, except under certain conditions, as follows:

1. In starting the cut.
2. In drilling in materials which do not themselves produce a sludge, such as bituminous filled brick or asphaltic surfaces.

For such drilling, one operator uses ⅓ crushed shot and ⅔ sand, others use a mixture of equal parts of crushed and spherical shot to which a small amount of sand is added (to which one operator adds a small amount of kerosine).

TABLE I. SHOT SIZES GENERALLY FURNISHED FOR CORE DRILLING.

MANUFACTURER	MANUFACTURER'S NUMBER	SIZE OF OPENING GIVEN BY MANUFACTURER, IN.
A	6	0.139
	7	0.115
	9	0.088
B	8	0.108
	12	0.093
	14	0.075
	2	0.111
	2½	0.102
	3 C	0.083
C	6	0.139
	7	0.115
	9	0.100

It is also reported that for drilling asphalt pavements, nicking the inner and outer faces of the drill bit with a cold chisel and the addition of a small amount of portland cement to the water under the cutting edge greatly facilitates the drilling.

Diamond Drills for Pavement Work.—Those who have attempted to use a diamond drill for pavement work report that they have found it unsuitable and that the cost is prohibitive being many times that of shot drilling. The reason given for the high cost is that the loss of diamonds through breakage is very great.

Other Types of Drills (*or Abrasives*).—Several operators have tried other materials and none are reported as being satisfactory for pavement drilling at this time.

Miscellaneous.—The time required to drill cores varies naturally with the materials encountered. One operator submits the following data, obtained from observations on the drilling of 111 cores from slabs 7 in. thick:

Aggregate, dense limestone	8 minutes per core
Aggregate, blast-furnace slag	9 minutes per core
Aggregate, siliceous gravel	13½ minutes per core

The amount of shot used varies with the time required for drilling, but appears to be from 1 to 3 lb. per core.

The amount of water required varies widely, the minimum reported being 1 gal. per core.

Steel shot are usually specified by number and this number varies with the manufacturer, as shown in Table I.

It is apparent that the sizes generally used do not vary widely and also that if a particular size is desired it will be necessary to specify a sieve opening.

APPENDIX IV

A STUDY OF THE ANALYSIS OF FRESH CONCRETE

By W. M. Dunagan[1]

The purposes of this paper are:

(*a*) To present the actual results of a large number of analyses of fresh concrete as a study of the accuracy of this particular method of test.

(*b*) To suggest uses of this test that will contribute to better field control of concrete.

(*c*) To present certain essential features in the behavior of portland-cement concrete while fresh that must be considered in the interpretation of the results of its analysis.

A test for determining the net amounts of significant ingredients used in a particular batch of concrete from an analysis of a sample has a definite place in present day practice, a few applications of which are:

(*a*) The "ready-mixed" concrete industry has created a need for an ability to analyze fresh concrete quickly.

(*b*) Strength specifications based upon water-cement or space-cement relationships determined from previous tests make it desirable to control the strength by maintaining these relationships or to predict the strength if they may be determined by test.

(*c*) Research into the properties, workability and uniformity factors of concrete need such a test to secure the information which it will give.

An analysis of fresh concrete to determine the water-cement ratio from a sample must be performed with extreme precision. This can be appreciated from the fact that the effective variations in the amount of water, which sets a standard for the accuracy required, is only one part in 500 parts of a sample tested.

A test for the analysis of fresh concrete should not be an independent test; there should be a direct relationship between it and the specific gravity and free moisture or absorption determinations. Control is simplified when the same apparatus is used in all control tests climaxing with the analysis of the concrete when desirable; in this respect the analysis sums up the other tests with a conclusive proof of their efficiency.

The data secured for this paper indicate that the test made use of in this study is reliable to the required degree; it is fundamental in nature requiring only careful work and a properly sensitive equipment.

History of Test Used in this Study

A complete description of the test used to secure the data discussed appears in Appendix V. This test is an outgrowth of an effort on the part of the author to unify all of the tests necessary to control the quality of portland-cement concrete. Specific gravity, free moisture, absorption and silt tests have been performed by a variety of methods with no correlation between them.

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[1] **Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa.**

By means of the buoyancy principle these tests were all performed successfully in the field by means of one set of inexpensive and rugged equipment. In further studies it became evident that the specific gravity of portland cement could be determined by means of the same equipment; this fact coupled with that of the passage of the cement through a No. 100 sieve made it obvious that fresh concrete could be analyzed using the data derived for use in the other tests. This test was then developed and used successfully in the Iowa State College Materials Laboratory and has since been used successfully in other places. In the few cases where operators have had difficulty in securing satisfactory results, certain important factors were overlooked. In order to present the technique of this test so that it may be performed successfully the author was requested to present his findings in the studies made to date. Special studies of strength factors and water loss are still under way; the portions submitted here are submitted only for the purpose of illustrating the uses and accuracy of the test itself.

This test is not an independent one; it can best be used when the specific gravity determinations and other tests are performed by the same method. This becomes perfectly obvious when it is realized that the term specific gravity is only a ratio and that this ratio derived under one condition should not be used in another.

PROCEDURE IN LABORATORY DURING STUDIES

In securing the data taken at Iowa State College the conditions were arranged to answer the following questions:

(*a*) Under what conditions can fresh concrete be analyzed accurately?

(*b*) What method of analysis is most practical in securing the required data?

(*c*) With a given method of procedure what accuracy can be expected in routine tests?

For these purposes the following arrangements were established:

(*1*) College undergraduates who had no previous experience with such a test were chosen as operators.

(*2*) All batches were mixed from saturated aggregates. This was done to avoid confusing results due to the rate of absorption encountered in using dry materials. Preceding each mix moisture determinations were performed upon the aggregates and corrections made.

(*3*) The coarse aggregate used was not uniform in specific gravity but it would have been possible to secure an aggregate uniform in this respect, however, the following was used as a practical consideration:

Coarse Aggregate; Screened River Gravel, No. 4 to $1\frac{1}{2}$ in.

CONSTITUENT PARTS OF A LARGE SAMPLE DESCRIPTION	PER CENT	SPECIFIC GRAVITY	ABSORPTION, PER CENT
Red Granite	21.7	2.66	0.46
Blue Granite	26.1	2.66	1.98
Limestone	22.6	2.66	1.50
Trap Rock	8.8	2.71	0.70
Chert	9.5	2.61	1.75
Sandstone	3.5	2.43	5.70
Doubtful	7.8	2.68	0.40
Average	...	2.67	1.4

Fine Aggregate: Screened River Sand.

	SPECIFIC GRAVITY
Specific Gravity	2.64
Absorption	0.80 per cent
Silt	0.8 per cent
Fineness Modulus	3.12

(*4*) Definition of "Net Quantities."—It will be observed later that this method of test presents the data found in terms of net quantities without correction. In order that the study be unified as to terms, all proportions are expressed in terms of net proportions by weight and the following definition of "Net Quantities" is used throughout.

(*a*) *Water.*—The net amount of water is considered to be the free water in the batch; it is that water available for the formation of a paste with the cement.

(*b*) *Aggregates.*—The net amount of aggregate is considered to be the actual amount of solid-material in the saturated and surface-dry condition; in such a condition the material would neither contribute water to nor absorb water from the water available for formation of a paste with the cement. With this basis of computing net quantities the following procedure is followed in proportioning a batch from aggregates in a field condition:

	SPECIFIED PROPORTIONS[a]	FIELD TESTS
Water	6¼ gal.	....
Cement	1 bag (94 lb.)	....
Sand	2 parts by weight (188 lb.)	5.20 per cent, free moisture
Stone	3½ " " " (329 ")	2.50 per cent, absorption

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[a] Determined from trial batch method or any accepted method.

$$\text{Therefore use: } \frac{188}{1.00 - 0.052} = 198.3 \text{ lb. of sand}$$

$$\text{Therefore use: } \frac{329}{1.00 + 0.025} = 321 \text{ lb. of stone}$$

MOISTURE CORRECTIONS

Sand contains 5.20 per cent of 198.3 = 10.3 lb. of water
Stone absorbs 2.50 per cent of 321.0 = −8.0 lb. of water

Net free water = 2.3 lb.

$$\text{Free Water} = \frac{2.3}{8.33} = 0.28 \text{ gal.}$$

Therefore, add: 6.25 − 0.28 = 5.97 or 6 gal. of water per bag of cement.

The advantage of this method of specifying quantities is that the net quantities used in the batch and the results of the analyses are in the same terms without corrections for absorption.

COMPARISON OF DIFFERENT METHODS FOR ANALYSIS

At the beginning of this study three methods of performing this analysis were considered and tried. These three methods have been described in other articles[1]; briefly they may be summarized as follows: All three procedures attempt to determine the amounts of the ingredients from their displacement rather than by drying them after the cement has been removed by washing through a No. 100 sieve. The first method, the one used in these studies, determines this displacement from the buoyancy of the materials; a second determines the displacement by means of the volume of water displaced in a cylinder using the same principle as that used in the A.S.T.M. flask for specific gravity determinations; a third method obtains the displacement by means of weighing a cylindrical container used as a pycnometer, this being the same principle as that used in the Iowa Highway Commission jar pycnometer for specific gravity and free moisture determinations. In all three cases the amount of cement is determined by the difference between the absolute volume of the entire sample and that of the aggregates only, thus eliminating the necessity for recovering the cement.

After trial it was discovered that all three methods produced the same data and that the matter of accuracy, speed of manipulation and flexibility of apparatus were the deciding factors.

REASONS FOR ADOPTION OF THE PROPOSED METHOD

The method proposed was adopted for the following reasons:

1. Neither of the other methods was flexible and they required special apparatus not suited for use in other tests. However, in the proposed method the specific gravity, free moisture and absorption tests were unified causing the control tests to become a series of connected tests rather than isolated determinations.

2. The accuracy required by the object of the test was such that no procedures of sufficient precision could be developed for the other two methods.

3. The method proposed permitted deferring the test. In using a cylinder as in the second method the water in the sample must be retained and its displacement noted; hence its loss through evaporation made the test inaccurate.

4. The proposed method combined the advantages of all three methods, as follows:

(*a*) Aggregates could be easily recovered and surface dried as a check, this being a necessity as in the second method, but not delaying the test; this feature was also had by the third method.

(*b*) The size of the sample was not limited. A large sample could be tested in sections while the apparatus could be kept small enough to be a portable field outfit for other uses.

(*c*) The buoyancy principle permitted greater accuracy in weighing with less expensive apparatus. It permitted the design of the separate parts to be inter-related to facilitate the handling of the materials with a minimum of losses in handling (a study of the equipment used will clarify this statement).

DATA NECESSARY FOR A COMPLETE ANALYSIS

To completely summarize the characteristics of a given sample of concrete so that its quality after setting may be interpreted from a knowledge of the significance of its constituents the following data should be secured:

1. Relative amounts of cement, fine and coarse aggregate.
2. Amount of water.

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[1] Discussion of "A Method of Determining the Constituents of Fresh Concrete," *Journal*, Am. Concrete Inst. Vol. 1, pp. 670–698 (1930).

3. Weight per unit volume.
4. Percentage of air voids.

Using the proposed buoyancy method all of these data are determined as illustrated in the following example of computations from a test:

1. Procedure in securing the data:

(*a*) Secure a representative sample of concrete.

(*b*) Rod the sample into a container of known volume, in this test, equal to 2005 cc.

(*c*) Analyze as follows:

Weight of sample in air	4913 g.
" " " immersed	2906.5 g.
" " coarse aggregate immersed	1483.5 g.
" " coarse and fine aggregates immersed	2420.5 g.
" " fine aggregate (by difference)	936.5 g.
" " cement (by difference)	486.0 g.

2. Computations:

(*a*) Specific gravity (previously determined) of materials:

	SPECIFIC GRAVITY
Cement	3.10
Sand	2.64
Coarse aggregate	2.66

(*b*) Convert weights immersed to weights in air as follows:

$$\text{Cement} = \frac{3.1}{3.1 - 1} \times 486.0 = 719 \text{ g.}$$

$$\text{Sand} = \frac{2.64}{2.64 - 1} \times 936.5 = 1462 \text{ g.}$$

$$\text{Coarse aggregate} = 2.66 \times 1483.5 = 2368 \text{ g.}$$

Total solids = 4549 g.

Water (by difference) = 4913 − 4549 = 364 g.

(*c*) Compute Density and Absolute Volume as follows:

	WEIGHT IN AIR	−	WEIGHT IMMERSED	=	ABSOLUTE VOLUME	PERCENTAGE OF TOTAL VOLUME
Entire sample:	4913	−	2906.5	=	2006.5 cc.	....
Coarse aggregate:	2368	−	1483.5	=	884.0 "	44.0
Fine aggregate:	1462	−	936.5	=	525.5 "	26.2
Cement:	719	−	486.0	=	233.0 "	11.6
Water:				=	364.0 "	18.2

(*d*) Mix Proportions:

Water-cement ratio $= \frac{364}{719} = 0.506$ by weight

" " " $= 0.506 \times 1.5 = 0.76$ by volume

Proportions by weight = 719:1462:2368 = 1:2.03:3.33

$$\text{Cement-space ratio: } \frac{c}{v + c} = \frac{233}{364 + 233} = 0.395$$

where c = absolute volume of cement, and

v = absolute volume of water.

This example serves to demonstrate all of the data possible to secure; it is not essential that the data relative to the absolute volumes be computed. Except in case of very dry concrete where the air voids may be excessive, the sample need not be measured in a container of known volume but may be of any size with the air voids assumed to be zero.

ACCURACY REQUIRED AS TEST FOR ANALYSIS OF FRESH CONCRETE

One of the first questions arising is that of the relative accuracy of the test. An analysis should be comparable in results with the constituents of the batch from which it was taken. In making such comparisons many deviations were found which proved to originate in an erroneous computation of the net ingredients of or in an improper sampling of the batch. This led to certain conclusions to be born in mind when similar comparisons are made.

(*a*) *Proportioning.*—In proportioning a batch from which samples are to be taken for analysis a degree of accuracy must be maintained consistent with the accuracy with which the analysis is to check the batch. For example, if it is expected to check within ¼ gal. of water per bag of cement the free moisture or absorption of the aggregates should be controlled within 0.2 per cent.

(*b*) *Sampling.*—Samples should be taken so that they are truly representative of the batch. It was found that samples taken from the small laboratory batches invariably contained an excess of coarse aggregate, this being due to sampling with a rounded scoop from a flat pan. For the mortar, exact checks may be obtained with small samples, with aggregates up to ¾ in., 3000-g. samples are adequate, with 1-in. aggregates 5000-g. samples, while with 1½-in. aggregates very large samples must be secured in order to check the aggregate constituents accurately. This again is a function of the consistency of the batch, dry batches being more easily sampled than wet ones.

(*c*) *Water-Cement Ratio Analysis.*—The analysis for water-cement ratio is the ultimate criterion of accuracy. The value of determining the amount of cement depends upon the relative amount of water so that it may be considered with the water as a ratio. It is commonly recognized that this ratio is of primary importance as a governing factor in concrete control; however, few testers realize the accuracy required of field testing to control the water factor within its significant amounts.

With a given unit volume of typical concrete the water is a relatively small percentage by weight. In a 1-bag mix containing the proportions 1:2½:4 by weight the total materials are about 760 lb., of this amount 56 lb. is water, or but 7.3 per cent by weight of the batch.

Since it is desirable that the water be controlled within ¼ gal. of water per bag of cement it is necessary that the water content be known to 2 lb.; thus the accuracy required is 2 lb. in 760 or $\frac{1}{380}$. To require an analysis to check the constituents of the above batch to $\frac{1}{10}$ gal. per bag is to require all work to be done to an accuracy of $\frac{1}{1100}$.

If absorption and free moisture tests are not being performed more closely than within 0.2 per cent, the analysis of the concrete should not be required to check closer than within 0.2 gal. of water per bag of cement. In the above mix the aggregate of 610 lb. with 0.2 per cent absorption would absorb 1.2 lb. or 0.15 gal.; thus with moisture control being no closer than 0.2 per cent, the concrete produced could be expected to contain either 5.85 gal. or 6.15 gal. when 6.00 gal. of water per bag of cement have been specified.

Thus it is apparent that when a sample of 3000 g. is taken from a batch for analysis, extreme accuracy must be observed if the results are to be significant. If in the whole process of weighing the sample, screening out the ingredients, determining their amounts, and in the computations an error of 5 g. is permitted, this error will equal $\frac{1}{10}$ gal. of water; this will be true regardless of the method of test. As an example, a batch of concrete mixed with room-dry aggregates capable of 0.5 per cent absorption was prepared and supposed to contain 6 gal. of water, the analysis showing it to contain 5.7 gal. was correct since the absorption correction amounted to this difference.

CRITICAL POINTS TO BE OBSERVED IN USE OF PROPOSED METHOD

Variations in Specific Gravity.—Errors from variations in specific gravity of coarse aggregates should be eliminated when the following points are recognized:

1. The specific gravity determination may be made very quickly and with the same equipment as used for the analysis; thus giving frequent checks on the value used.

2. The coarse aggregate from a given test may be checked by drying. This is better done by surface drying the coarse aggregate from the test, weighing it immersed and computing the specific gravity from the actual sample used. In case some material is lost in the drying no error is then introduced; this amounts to correcting by proportion. The following is an example of this procedure:

	MIX	SPECIFIC GRAVITY
Coarse aggregate	35 lb.	2.65[a]
Sand	35 lb.	2.64
Cement	10 lb.	3.10
Water	7.25 gal.	....

---

[a] Average value (questionable).

First Analysis (Correct):

	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.
Entire sample	2336.0	4000
Coarse aggregate	1020.0	1640
Fine aggregate	1016.0	1632
Cement (by difference)	300.0	442
Water (by difference)	....	286
Water-cement ratio	7.3 gal. of water per bag of cement.	

A portion of the coarse aggregate was recovered and surface dried. This portion, 1500 g., immersed, weighed 937 g. which checks the value of 2.65 used, or in other words $\frac{937}{1500} = \frac{1020}{1640}$.

Second Analysis (Incorrect):

	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.
Entire sample	2350	4000
Coarse aggregate	1058	1700
Fine aggregate	993	1600
Cement (by difference)	301	443
Water (by difference)	...	257
Water-cement ratio	6.6 gal. of water per bag of cement.	

A portion of the coarse aggregate was recovered and surface dried. This sample, 1500 g. immersed, weighed 943 g. Thus in this sample the coarse aggregate had a specific gravity of 2.69. Substituting in the second analysis, the coarse aggregate then will be found from the proportion:

$$\frac{943}{1500} = \frac{1058}{X}; \; X = 1683 \text{ g. instead of } 1700 \text{ g.}$$

The correct results of the analysis then being: coarse aggregate, 1683 g.; fine aggregate, 1600 g.; cement, 442 g.; water, 276 g.; and the water-cement ratio, 7.2 gal. per bag of cement.

Size of Sample.—Samples weighing 3 to 4 kg. were used in the Ames test for the purpose of keeping the apparatus within a practical size for field use. The sample is not limited to this size, a single sample of 12 kg. may be selected and tested in a series of four 3-kg. increments, the results then calculated for the summation.

Accuracy of Specific Gravity Determination of Portland Cement from its Buoyancy.—The adoption of the whole method of test originated in the verification of the fact that this test could be accurately performed. The author had used his apparatus for the specific gravity of fine and coarse aggregates; it occurred to him that if portland cement could be likewise tested in this manner an analysis of the concrete could be performed with the same equipment. In such a determination it was found that very consistent and accurate tests could be performed on portland cement.

Silt Variation in Sand, and Percentage of Cement Retained on the No. 100 Sieve.—Data for use in correcting for this factor is easily obtained when samples of the material are available.

Example: 1000 g. of fine aggregate, wet:

Weight immersed	620 g.
Wash over No. 100 sieve, reweigh immersed	608 g.
Add 500 g. cement, reweigh immersed	947 g.
Wash over No. 100 sieve, reweigh immersed	615 g.

$$\text{The silt loss} = \frac{620 - 608}{608} = 2.0 \text{ per cent}$$

$$\text{Specific gravity of cement} = 947 - 608 = 337; \; \frac{500}{500 - 337} = 3.10$$

$$\text{Cement retained on the No. 100 sieve} = 615 - 608 = 7; \; \frac{7}{337} \times 100 = 2.1 \text{ per cent}$$

ACCURACY OF THE TEST AS USED

Example of an Ideal Test.—(Entire batch tested as a sample):

	MIX USED	SPECIFIC GRAVITY
Entire sample	3886 g.	....
Stone	1500 g.	2.69
Sand	1500 g.	2.64
Cement	500 g.	3.10
Water	386 g.	....

Method of Procedure.—The above ingredients were mixed in a pan and tested by washing immediately into the testing device. It will be observed, from the following results obtained with this method, that had the solid materials been mixed dry and tested the same data would have been obtained. With water added the only difference would have been the weight of the sample in air. This is an important point to observe in interpreting results of trials of the accuracy of this test.

	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.
Sample	2215.5	3886
Rock	932.5	1500
Sand	944.0	1500
Cement (by difference)	339.0	500
Water (by difference)	....	386

Example of the Analysis of a Portion of a Batch.—The following tests were performed as demonstrations of the use of this equipment; they illustrate the accuracy of the test under favorable conditions. At the Illinois Highway Commission Laboratory a batch was mixed and two samples from it analyzed by two operators; the results show two things (1) the accuracy of the test and (2) the manner in which two operators may check each other:

BATCH USED

	GROSS WEIGHT	CORRECTION	NET WEIGHT	MIX PROPORTIONS
Cement, g	2270	0	2270	1
Sand, g	5000	−450	4550	2.01
Stone, g	6000	− 66	5934	2.61
Water, g	544	+516	1060	....
Water-cement ratio	0.70 or 5.25 gal. per bag of cement			

RESULTS OF ANALYSES

	OPERATOR NO. 1		OPERATOR NO. 2	
	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.
Entire sample	1758.5	3000	2354.5	4000
Rock	790.4	1269	1165.8	1870
Sand	634.9	1015	772.2	1235
Cement (by difference)	333.2	491	416.5	615
Water (by difference)	....	225	....	281
Water-cement ratio	0.69 or 5.15 gal. per bag of cement		0.69 or 5.15 gal. per bag of cement	
Mix ratio	491:1015:1269 or 1:2.03:2.58		615:1235:1870 or 1:2.00:3.05	

The data shown in Table I were secured in the laboratory of the Minnesota Highway Commission. These tests were performed for the purpose of determining (1) the accuracy of the test (2) the accuracy with which a single operator could duplicate his work from a batch and (3) the accuracy with which two operators could check each other.

Table I.—Summary of Analyses Made by Minnesota Highway Laboratory.

Specific Gravities: Limestone, 2.62; Sand, 2.68; Cement, 3.10
Operators Numbered 1 and 2, Each Performing Two Tests, A and B

	Test 1A	Test 1B	Test 2A	Test 2B	Average
Batch No. 1:					
Water-cement ratio, gal. per bag of cement	4.74	4.76	4.83	4.85	4.90
Proportions	1:1.99:2.81	1:2.04:3.07	1:2.07:3.19	1:2.035:3.15	1:2.03:3.04
Batch No. 2:					
Water-cement ratio, gal. per bag of cement	4.45	4.67	4.60	4.96	4.68
Proportions	1:2.07:3.31	1:2.11:2.96	1:1.95:2.84	1:2.05:3.17	1:2.05:3.06
Batch No. 3:					
Water-cement ratio, gal. per bag of cement	4.76	4.86	5.05	4.82	4.88
Proportions	1:2.10:3.16	1:2.17:3.19	1:2.07:3.01	1:2.11:3.19	1:2.11:3.12
Batch No. 4:					
Water-cement ratio, gal. per bag of cement	4.70	4.76	....	....	4.74
Proportions	1:1.86:2.72	1:1.88:2.45	....	....	1:1.87:2.58

Sensitiveness of the Test

One of the requirements of such a test is that it be able to detect significant variations in a given mix.

In the following test analyses the same mix was used a number of times with variations in the amounts of water used; these variations are reflected in the plasticity of the concrete as shown in the slump test. With each variation in slump a new analysis was made.

Test Analyses Results

	Slump, in.	Mix Ratio	Water-Cement Ratio, gal. per Bag of Cement
Mix Used (by weight) 1:2.0:3.0	1½	1:2.0 :3.3	5.23
	3	1:1.95:3.3	5.30
	6	1:2.1 :3.2	5.76
	10	1:2.07:3.3	5.90
Mix Used (by weight) 1:1.5:1.5	0	1:1.52:1.37	3.40
	0	1:1.50:1.75	3.65
	2	1:1.49:1.60	3.75
	3	1:1.51:1.55	4.15
	5	1:1.50:1.70	4.30
	10	1:1.50:1.72	4.80

Special Features of Use of Test

Tests Deferred over Period of Time.—In the following tests the batch was mixed and eight 3000-g. samples selected at once; these were then tested at intervals of time as noted:

Mix Used:

Water-Cement Ratio..5.1 gal. per bag of cement 3.75 gal. per bag of cement

SAMPLE NUMBER	TIME TESTED AFTER MIXING	WATER-CEMENT RATIO FOUND BY TEST	SAMPLE NUMBER	TIME TESTED AFTER MIXING	WATER-CEMENT RATIO FOUND BY TEST
1[a]	20 min	5.13	1	10 min	3.66
2[a]	40 min	5.12	2	25 min	3.60
3[a]	55 min	5.09	3	50 min	3.63
4[a]	1 hr. 20 min	5.00	4	1 hr. 50 min	3.90
5	1 ht. 50 min	5.15	5	1 hr. 50 min	3.81
6	2 hr. 10 min	5.12			
7	2 hr. 35 min	5.15			
8	3 hr	5.10			

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[a] The first four tests were performed without changing the water used for immersing the sample. The remaining tests were each performed in fresh water.

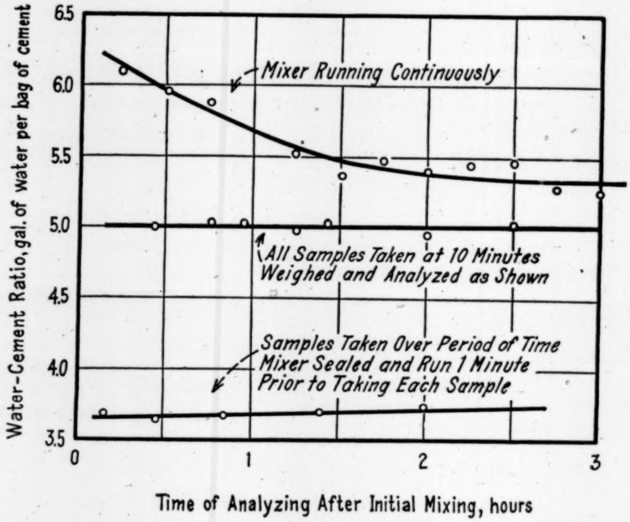

FIG. 1.—Effect on Result of Elapsed Time Between Mixing and Analyzing Concrete Samples.

These results show that tests may be made successfully on samples weighed immediately after mixing and tested at any time before too hard to break up. This fact is further shown in Fig. 1.

Following this a series was tested in which four samples were selected, two tested at once and two analyzed after being frozen for 24 hours.

SAMPLE NUMBER	TIME TESTED AFTER MIXING	MIX RATIO	WATER-CEMENT RATIO, GAL. PER BAG OF CEMENT
1	Immediately	1:1.97:2.62	4.77
2	Immediately	1:1.93:3.50	4.60
3	24 hours frozen	1:1.90:2.96	4.70
4	24 " "	1:1.93:2.41	4.83

As a result of these tests it is seen that samples may be selected and treated with sugar or by freezing to retard hardening and analyzed at a later time.

Analysis of Mortar Screened from a Sample.—In the analyses performed in this study the cement-fine aggregate relation was more accurately checked than that of the other constituents. This pointed to the significant feature of determining the quality of fresh concrete from a sample of mortar screened from the batch.

According to the water-cement relationship the quality of the concrete is determined by the relation between the cement and water only, while according to Talbot and Richart the quality may be determined from the cement-fine aggregate-void ratio and the amount of coarse aggregate is not significant in establishing its quality; it only effects the plasticity.

Since the amount of coarse aggregate is not significant and since the coarse aggregate contains the feature most likely to introduce error into a test for the constituents of the fresh concrete the author questioned the advisability of testing samples containing coarse aggregates in all cases. Investigation was made to ascertain the relation between the data obtained when the entire sample is analyzed and that where a sample of the mortar only is tested. The procedure in these tests was as follows:

Sample No. 1.—A sample was secured from a known batch containing aggregate up to 2 in. in diameter.

Sample No. 2.—A large sample of the mortar was screened from the batch and analyzed.

Sample No. 3.—A very small sample was secured, weighed in a 2 by 4-in. cylinder and analyzed.

Batch Used:

SLUMP	WATER	CEMENT	SAND	ROCK
4 in.	2.4 lb.	5 lb.	11 lb.	16.5 lb.
Mix Proportions		1	2.2	3.3

Water-cement ratio { 0.48
5.4 gal. per bag of cement

TEST ANALYSES RESULTS

Sample No. 1. (Concrete):

	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.	MIX PROPORTIONS
Entire Sample	2888	4877	....
Rock	1623	2602	4.15
Rock and sand	2460	....	....
Sand	837	1343	2.15
Cement (by difference)	428	627	1
Total solids		4572	
Water (by difference)		305	

Water-cement ratio............ 0.485 or 5.47 gal. per bag of cement

Sample No. 2. (Mortar):

	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.	MIX PROPORTIONS
Entire Sample	1543	2766	...
Sand	1036	1664	2.2
Cement (by difference)	507	743	1
Total solids		2407	
Water (by difference)		359	

Water-cement ratio............ 0.483 or 5.45 gal. per bag of cement

Sample No. 3.[a] (Mortar):

	WEIGHT IMMERSED, G.	WEIGHT IN AIR, G.	MIX PROPORTIONS
Entire Sample	261.7	470	...
Sand	174.6	280.4	2.2
Cement (by difference)	87.1	127.6	1
Total solids		408.0	
Water (by difference)		62	
Water-cement ratio	0.483 or 5.45 gal. per bag of cement		

---

[a] Sample No. 3 was obtained in cylinder with volume of 206 cc. The absolute volume of the sample = 470 − 261.7 = 208.3. In this case no air voids are indicated.

Conclusions:

(*a*) The analysis for water-cement ratio of a batch may be performed with precision upon a sample from which the coarse aggregate has been removed. This is true of any sample regardless of the size of the coarse aggregate; it should have significance in governing the quality of mass concrete where large aggregate is used.

(*b*) The speed of an analysis is increased since only one aggregate is tested.

(*c*) The accuracy is increased due to the removal of one important variable, the variation in specific gravity of the coarse aggregate.

(*d*) The sample may be much smaller in size, giving an accurate test.

STUDY OF THE ANALYSIS OF A BATCH OF CONCRETE AS COMPARED TO AN ANALYSIS OF THE CONCRETE AFTER PLACING

Considerable attention has been called to the so-called "water gain" or loss in water from concrete after placing. This point received attention at the 1930 Annual Meeting of the Society during discussions of Mr. Collier's paper.[1]

In order to secure information upon this subject and to anticipate further uses for analyses of fresh concrete the following studies were made:

1. Study of the time necessary for "water gain" to become complete. The results of this study are shown in Table II. A series of cylinders were prepared of concrete of various consistencies; these cylinders were broken down and analyzed at various intervals of time.

Conclusions: Water gain is not complete as judged by results on concrete from the top and bottom of the cylinder having the same water-cement ratio, for a period of 1½ hours. From this fact all other cylinders were tested at 2 hours.

This is further verified in column studies in which the concrete from top to bottom of 6-ft. columns was found to have a uniform water content after 2 hours, this content being constantly different from the batch used.

2. A series of cylinders was analyzed after 2 hours and the results compared with analyses of samples taken from the batches from which they were made. These specimens were from different mixes of varying consistencies.

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[1] Ira L. Collier, "Variations of Compressive Strength of Concrete Within the Water-Cement Ratio Law," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part II, p. 731 (1930).

Conclusions: Figures 2 and 3 give the results of this study. It is shown that samples from dry batches with no slump have no water gain, the analysis of the cylinder and the sample from the batch being identical. It is interesting to note that in these cylinders the water content of concrete from the bottom of the cylinder is higher than that from the top (see Table II). Over the plastic range there is nearly a constant loss of water, increasing until with wet batches a high loss is shown.

TABLE II.—SUMMARY OF TESTS ON CONCRETE CYLINDERS TO DETERMINE TIME AT WHICH WATER-CEMENT RATIO BECAME CONSTANT.

Proportions same in all mixes, water varied in order to change plasticity.

Slump	Source of Sample	Time Tested After Casting	Water-Cement Ratio, Gal. per Bag of Cement	Loss, Gal. per Bag of Cement
	MIX No. 1			
None (dry)	Batch	15 min.	5.40	...
	Batch	30 min.	5.40	...
	Cylinder (bottom)	1 hr.	5.60	...
	Cylinder (top)	1 hr.	5.50	...
	Cylinder (bottom)	2 hr.	5.70	0
	Cylinder (top)	2 hr.	5.40	...
	MIX No. 2			
1 in.	Batch	15 min.	7.2	...
	Batch	30 min.	6.9[a]	...
	Cylinder (bottom)	30 min.	6.9	0.10
	Cylinder (top)	30 min.	6.6	0.40
	Cylinder (bottom)	1 hr.	6.3	0.70
	Cylinder (top)	1 hr.	7.0	0.00
	Cylinder (bottom)	2 hr.	6.25	0.75
	Cylinder (top)	2 hr.	6.40	0.60
	MIX No. 3			
4 in.	Batch	15 min.	8.00	...
	Batch	30 min.	8.00	...
	Cylinder (bottom)	30 min.	7.60	0.40
	Cylinder (top)	30 min.	7.90	0.10
	Cylinder (bottom)	1 hr.	7.80	0.20
	Cylinder (top)	1 hr.	8.00	0.00
	Cylinder (bottom)	2 hr.	7.30	0.70
	Cylinder (top)	2 hr.	7.20	0.80
	MIX No. 4			
Sloppy	Batch	15 min.	10.7	...
	Cylinder (bottom)	30 min.	8.9	1.8
	Cylinder (top)	30 min.	8.9	1.9
	Cylinder (bottom)	1 hr.	8.7	2.0
	Cylinder (top)	1 hr.	9.0	1.7
	Cylinder (bottom)	2 hr.	8.9	1.8
	Cylinder (top)	2 hr.	9.00	1.7

[a] Average, 7.0.

3. A series of columns 6 in. in diameter and 6 ft. in height was analyzed after 2 hours and the results compared with analyses of samples taken from batches from which they were made.

Conclusions: See Fig. 4. These mixes being of plastic nature lost about 0.5 gal. of water, and became uniform from top to bottom.

Behavior of Fresh Concrete When Placed in Columns.—During a study of the relative strength of columns from top to bottom, analyses were made of

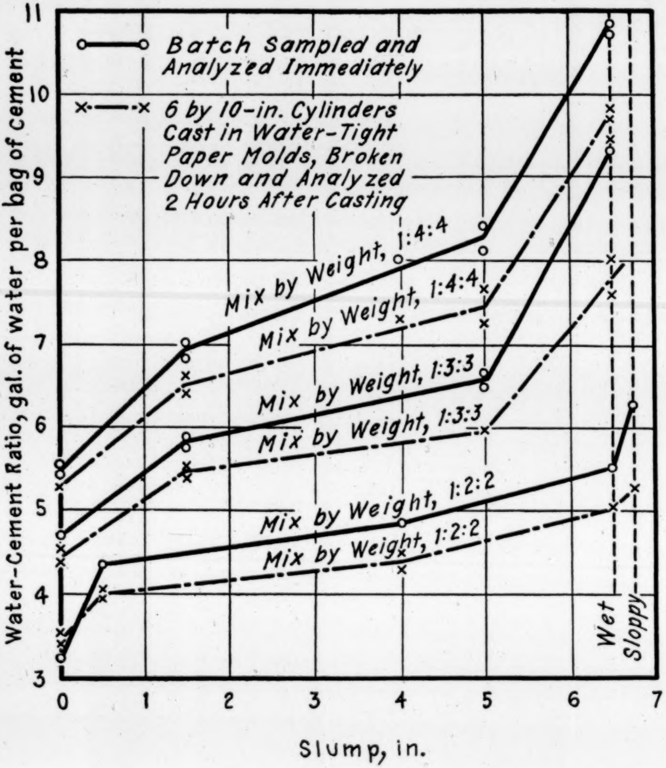

FIG. 2.—Study of Water Loss in Cylinders.

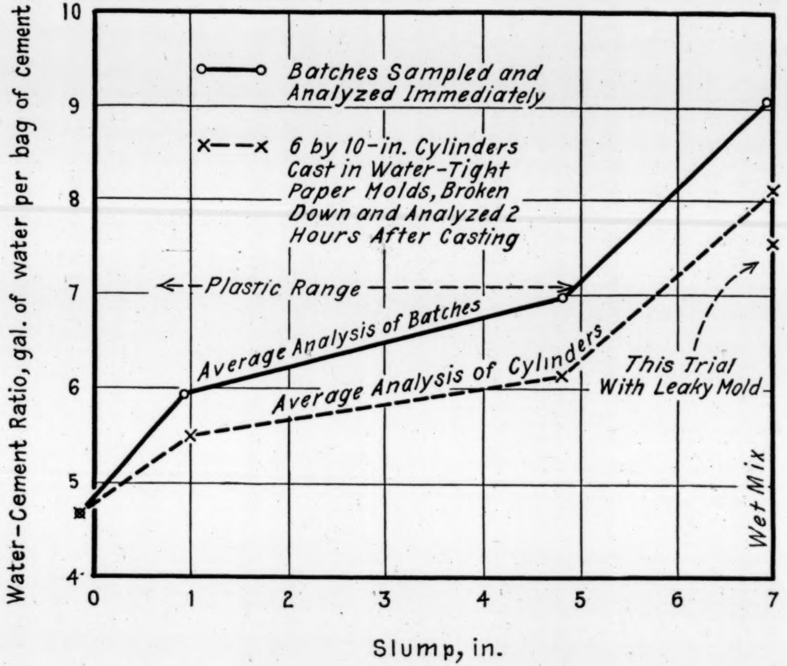

FIG. 3.—Study of Water Loss in Cylinders, Average Results.

the ingredients of the concrete just prior to hardening. This necessitated numerous analyses. The results of these analyses are presented here for two reasons:

1. To show the consistent nature of the analyses.

2. To show an example of the results of sampling concrete that has been placed.

Procedure:

(*a*) Saturated aggregates were used.

(*b*) Two analyses were made from each of two batches necessary to fabricate the specimens, making four analyses of the concrete used.

(*c*) Three columns 6 in. by 6 ft. were constructed using stove pipe for molds, these being practically water tight. Two hours after the filling of the columns one was opened and sampled at six places from top to bottom.

(*d*) Three 6 by 12-in. cylinders were made. After 2 hours one was opened and a sample analyzed from the top and bottom of the cylinder.

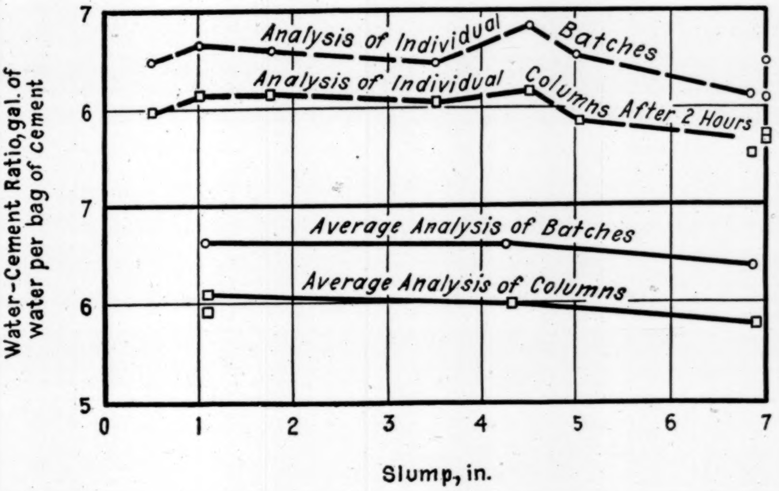

FIG. 4.—Study of Water Loss in Columns, Aggregates Varied, All Mixes Plastic.

Conclusions from Column Tests:

1. A definite water gain took place in all columns which ceased at some time prior to 2 hours, at this time the concrete from top to bottom of the columns was practically uniform in water content.

2. The only concrete not showing this loss was that too dry to be called plastic.

3. The 6 by 12-in. cylinder and the 6 in. by 6-ft. column showed the same loss.

4. Concrete taken from forms and analyzed cannot be expected to have the same water content as that of the batch from which it was made.

STRENGTH TESTS

A series of specimens was prepared from batches of plastic concrete. From each batch a sample was secured and analyzed. At 28 days the specimens

TABLE III.—STUDY OF WATER-GAIN IN CYLINDERS AND COLUMNS.
(Results given in terms of gallons of water per bag of cement.)

Mix Number	Source of Sample					
	Batch		6 by 12-in. Cylinder		6-in. by 6-ft. Column	
	Sample Number		Sample Number		Sample Number	
No. 1	1	7.0	1	6.25 top	1	6.16 bottom
	2	6.92	2	6.20 bottom	2	6.25
	3	6.80			3	6.05
	4	7.0			4	6.0
					5	6.18
					6	5.50 top[a]
No. 2	1	6.70	1	6.35 top	1	5.4 bottom
	2	6.35	2	6.40 bottom	2	6.3
	3	6.78			3	5.9
	4	6.6			4	5.85
					5	5.9
					6	6.05 top
No. 3	1	6.75	1	5.90 bottom	1	6.30 bottom
	2	6.75	2	6.6 top	2	5.95
	3	6.80			3	6.2
	4	6.50			4	6.4
					5	6.3
					6	6.25 top
No. 4	1	6.6	1	5.65 bottom	1	5.85 bottom
	2	6.6	2	5.85 top	2	6.30
	3	6.75			3	5.90
	4	6.60			4	6.40
					5	6.60
					6	6.30 top
No. 5	1	6.6	1	5.2 bottom	1	5.95 bottom
	2	6.4	2	5.54 top	2	5.85
	3	6.6			3	6.1
					4	5.9
					5	5.9
					6	6.3 top
No. 6	1	6.68	1	5.9 top	1	5.75 bottom
	2	6.50	2	6.0 bottom	2	6.1
	3	6.45			3	6.1
	4	6.65			4	6.4
					5	6.0
					6	6.15 top
No. 7	1	6.50	1	5.50 top	1	5.5 bottom
	2	6.40	2	5.85 bottom	2	5.7
	3	6.50			3	5.65
	4	6.62			4	5.60
					5	5.05
					6	5.90 top
No. 8	1	6.37	1	5.57 top	1	5.72 bottom
	2	6.20	2	6.08 bottom	2	5.90
	3	6.06			3	5.60
	4	6.15			4	5.0
					5	5.8
					6	5.87 top
No. 9	1	6.34	1	5.83 top	1	5.55 bottom
	2	5.90	2	5.60 bottom	2	6.10
	3	6.30			3	5.84
	4	5.95			4	5.50
					5	6.08
					6	5.85 top

[a] Low value due to evaporation.

were crushed and the compressive strength plotted against the results of the analyses.

Figure 5 shows the compressive strength plotted against the water-cement ratio as determined from analysis.

Figure 6 shows the compressive strength plotted against the percentage of ingredients by absolute volume as shown by the analysis.

These data are presented here mainly for the purpose of illustrating the accuracy of the test for the analysis of the concrete.

The water-cement ratio curve does not coincide with the curve $\frac{14\,000}{7x}$; the fact that it is a straight line is possibly due to the small number of specimens. This curve is drawn from points representing an average of only two specimens.

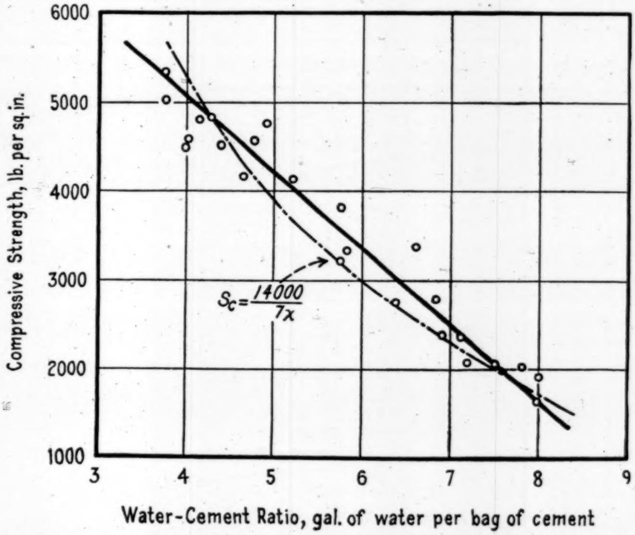

FIG. 5.—Relation Between Compressive Strength and Water-Cement Ratio, Results of 20 Analyses.

The percentage of total volume graph, Fig. 8, takes this form because only plastic batches were used. With very wet or dry batches this relationship would break down.

SUMMARY FOR ALL STUDIES

1. Concrete may be analyzed successfully under the following conditions:

(*a*) Samples secured so that they are representative.

(*b*) Samples secured of a size such that the size of the aggregate will permit checking of the ingredients.

(*c*) Samples taken from concrete in place not expected to contain the same water as that used in the batch.

(*d*) The sample secured and weighed at an early period and tested before hardening or by retarding the setting artificially.

(*e*) When data have been secured upon the following characteristics of the materials used:

1. Specific gravity of aggregates.
2. Silt content of the fine aggregates.
3. Fineness of the cement.

(*f*) When the water-cement ratio only is desired it may be secured quickly and reliably from an analysis of a sample of the mortar only.

2. With reasonable data secured concerning the aggregates, the water-cement ratio may be checked to $\frac{1}{10}$ gal. per bag of cement; it may be relied upon within $\frac{1}{4}$ gal. For research purposes where aggregates may be chosen carefully analyses should be exact. The fine aggregate-cement relations may be determined accurately without difficulty; the coarse aggregate relations depending upon accuracy in sampling.

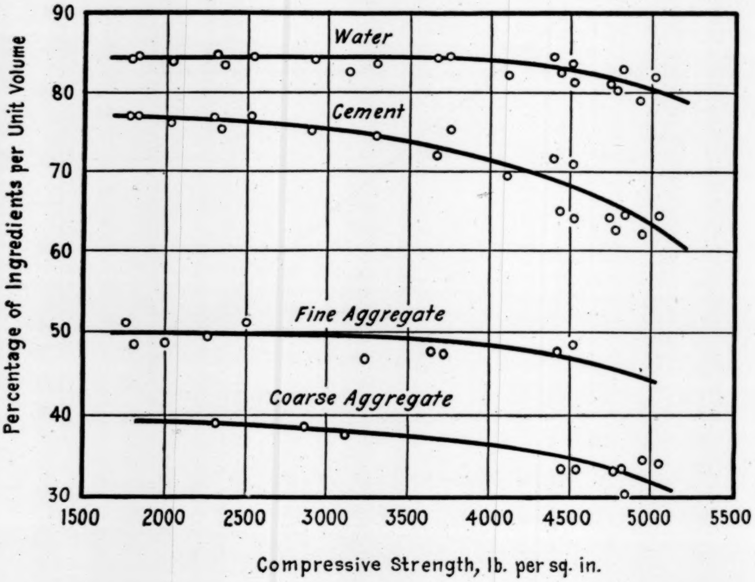

FIG. 6.—Relation Between Compressive Strength and Mechanical Analysis, Results of 20 Analyses.

3. This test may be used to facilitate the enforcing of specifications in the following situations:

(*a*) Determination of the segregation occurring in mixing and placing in order to establish uniformity.

(*b*) To determine the efficiency of various mixers or conveyances for concrete.

(*c*) To determine the water-cement ratio of a batch from a quick analysis of the mortar screened from a sample.

(*d*) Where proportioning has been accomplished by volume, analyses of samples will verify the accuracy of bulking factor corrections particularly through the ability of the test to determine cement-fine aggregate relations.

4. More study is necessary in determining just what the "significant ingredients" of a sample of concrete are.

(*a*) It is essential that a relationship be established between the strength of concrete and the actual water-cement ratios at a period of 2 hours after placing.

(*b*) Relations between the water, cement and fine aggregates should be established to meet the situation of analyzing only the mortar from a sample containing very large aggregates.

5. In view of the findings of this study coupled with experience in practical use of this test it is recommended that the analysis of fresh concrete be performed according to the proposed method of test.

DISCUSSION

Mr. R. W. Crum.[1]—The results of the test described by Mr. Dunagan depend on a knowledge of the apparent specific gravity of the aggregates, and this factor is of great importance also in controlling concreting operations in the precise way that is now in frequent use. I should like to suggest the desirability of making a sufficient number of tests so that the probable error in the determination of apparent specific gravity by the standard method could be determined by statistical analysis. This would involve several hundred determinations on samples of an aggregate of known uniformity. It would also be desirable to make similar extensive series of tests on the products of some typical sources of supply so that by statistical methods the probable variation in apparent specific gravity of material as delivered to the work could be ascertained.

Mr. W. M. Dunagan[2] (*author's closure by letter*).—This test for analysis of fresh concrete can be carried out without previous knowledge of the specific gravity of the aggregates, this being accomplished by recovering the aggregates and surface drying them. Its principal advantage in this case is that it is not necessary to recover the cement, a procedure making such a test almost impossible. It seems apparent that many alleged variations in specific gravity, particularly in coarse aggregates, may be attributed to differences in method of test for and in definition of the term specific gravity; with the more careful standardization of the method of test and definition just recommended by Committee C-9 closer agreement should be found between values derived for the same material. With the more general use of proportioning by weight, estimation of quantities by sums of absolute volumes and limitation of net water present in a batch, the term specific gravity assumes a more important place in the field of concrete; Mr. Crum's suggestions for study of its fluctuations should by all means be carried out.

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[1] Director, Highway Research Board, National Research Council, Washington, D. C.

[2] Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa.

APPENDIX V

PROPOSED METHOD OF TEST FOR THE FIELD DETERMINATION OF THE CONSTITUENTS OF FRESH CONCRETE[1]

1. *Scope.*—This method of test is intended for use in the field for making determinations, prior to the initial hardening, of the relative amounts of water, cement, fine aggregate and coarse aggregate present in concrete.

2. *Apparatus.*—The apparatus shall be suitable for determining the absolute volume of material from its buoyancy in water to an accuracy within 0.5 g. A satisfactory apparatus is shown in Fig. 1.

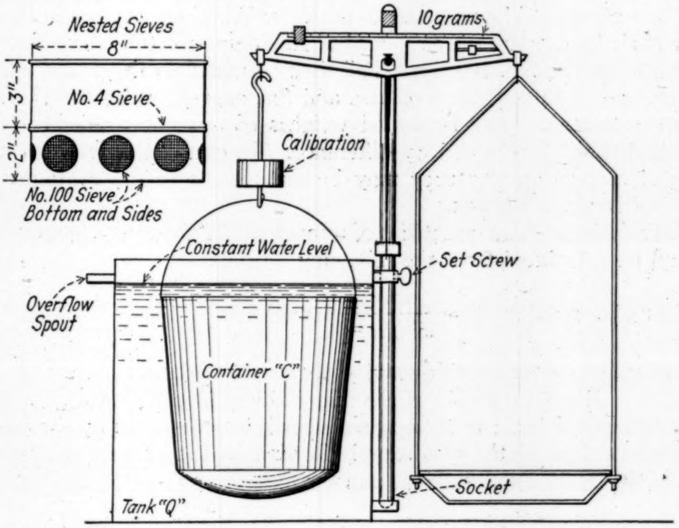

FIG. 1.—Apparatus for Determining Buoyancy of Materials in Water.

3. *Specific Gravity.*—The specific gravity of the fine and coarse aggregates in a saturated and surface dry conditions and of the cement used in making the concrete shall be determined.

4. *Sample.*—A representative quantity of the fresh concrete shall be selected from the mixer discharge or from the portion of the work under construction that may be specified; this representative sample shall be large enough to permit quartering to a test sample weighing between 3 and 4 kg.

5. *Procedure.* (*a*) *Weight of Test Sample in Air.*—The test sample shall be accurately weighed in air to the nearest 0.5 g. without picking over, since

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[1] Criticisms of this proposed method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

this may change the proportions. Where density measures are desirable the sample shall first be rodded into a mold of known volume and then weighed. After weighing the sample the test may be deferred until a later period since losses by evaporation do not affect the results of the test.

(*b*) *Weight of the Test Sample Immersed in Water.*—The weight of the test sample immersed in water shall be accurately determined. With the apparatus shown in Fig. 1 this determination shall be made as follows: The container *C* shall be removed and filled one-quarter full of water, the test sample poured into it and stirred to remove entrained air. The container *C* shall then be completely filled with water and allowed to settle for one minute. The weight of the sample immersed in water shall then be determined to the nearest 0.5 g. by suspending the container in the tank of water *Q*.

(*c*) *Weight of Aggregates and Cement Immersed in Water.*—The sample shall then be poured on nested No. 4 and No. 100 sieves and all of the cement that will pass the No. 100 sieve carefully washed through. Care shall be taken in all handling that none of the aggregate is lost. The coarse aggregate retained on the No. 4 sieve shall be poured into the container *C* and its weight immersed in water shall be determined as described in Paragraph (*b*). The fine aggregate retained on the No. 100 sieve shall then be added to the coarse aggregate and the weight of the combined coarse and fine aggregates immersed in water shall be determined. The immersed weights of the fine aggregate and the cement shall then be obtained by difference. In case the aggregates may be of doubtful specific gravity they may be removed from the container, dried and weighed in air as a check.

6. *Calculations.*—The quantities of cement and of the coarse and fine aggregates shall be calculated from the following formula:

$$\text{Weight of material in air} = \frac{\text{sp. gr.}}{\text{sp. gr.} - 1} \times W$$

where sp. gr. = the specific gravity of the material, and
W = the weight of the material immersed in water.

The amount of water in the original sample is determined by the difference between the weight of the test sample in air and the sum of the calculated weights of the cement and fine and coarse aggregates.

Example.—The following example will illustrate the application of the test:

Data on Materials:

Specific gravity of coarse aggregate	2.55
Specific gravity of fine aggregate	2.65
Specific gravity of cement	3.10
Weight of test sample in air	3000 g.
Weight of test sample immersed	1683 g.
Weight of coarse aggregate immersed	810 g.
Weight of coarse and fine aggregate immersed	1373 g.
Weight of fine aggregate immersed (by difference)	563 g.
Weight of cement immersed (by difference)	310 g.

Calculations:

$$\text{Cement} = \frac{3.1}{3.1 - 1} \times 310 = 458 \text{ g., weight in air.}$$

$$\text{Fine aggregate} = \frac{2.65}{2.65 - 1} \times 563 = 905 \text{ g., weight in air.}$$

$$\text{Coarse aggregate} = \frac{2.55}{2.55 - 1} \times 810 = 1332 \text{ g., weight in air.}$$

Total solids = 2695 g.

Water (by difference) = 305 g.

Mix Found by Test:

	WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
Weight in air, g.	305	458	905	1332
Parts by weight	7½ gal.	1	2	2.94

$$\text{Water-cement ratio} \begin{cases} \text{by weight} = \dfrac{305}{458} = 0.667 \\ \text{by volume} = 0.667 \times 1.5\text{[a]} = 1.0 \end{cases}$$

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[a] Water-cement ratio by weight is converted to a volume ratio by multiplying by 1.5.

APPENDIX VI

DETERMINING THE CEMENT CONTENT OF SET CONCRETE BY CHEMICAL METHODS OF ANALYSIS

By H. F. Kriege[1]

Some of the data obtained by the application of the proposed Tentative Method of Routine Analysis of the Cement Content of Portland Cement Concrete to various forms of concrete are given below. Most of the specimens were taken from briquets, beams, and cylinders prepared in the laboratory for tensile strength, flexural and crushing strength tests, respectively. The kind of cement, the kinds of aggregates and weights of each used were recorded but were unknown to the operator until the analysis had been completed.

Since the constituent determined is but a small part of the original sample, four or five portions of the same sample were run in most cases. This gave information as to the reliability of the method, since it would be worthless if there was not fair uniformity in the various check analyses on the same sample. An extreme variation of more than 0.4 per cent SiO_2 was found in only a few cases. This variation was usually less than 0.15 per cent. A brief description of each series accompanies the data thereof.

	Mix Found	Cement, per cent	True Mix Used	Cement, per cent	Samples Run	Description of Sample
No. 1	1:5.29	15.89	1:5.35	15.75	6	White flint and limestone aggregate, Missouri river sand, beam.
No. 2	1:3.1	24.40	1:3.0	25.00	2	Ottawa sand, Briquet.
No. 3	1:5.75	14.87	1:5.67	15.00	4	Ottawa sand, Briquet.
No. 4	1:4.42	18.46	1:4.35	18.69	4	Joplin flint, chats, cylinder.
No. 5	1:5.00	16.67	1:5.30	15.87	4	Disintegrated chert, natural sand, cylinder.
No. 6	1:6.29	13.74	1:5.82	14.67	5	Weathered flint, crushed flint, cylinder.
No. 7	1:6.35	13.61	1:5.82	14.67	4	Weathered flint, crushed flint, cylinder.
No. 8	1:5.69	14.94	1:5.70	14.95	4	Bethany Falls limestone, Missouri river sand, cylinder.
No. 9	1:6.07	14.16	1:5.82	14.67	3	Weathered flint, crushed flint, cylinder.
No. 10	1:5.08	16.45	1:5.24	16.04	4	Weathered flint, crushed flint, cylinder frozen 5 times.
No. 11	1:5.10	16.40	1:5.24	16.04	4	Weathered flint, crushed flint, cylinder not frozen.
No. 12	1:5.96	14.40	1:5.80	14.71	5	Meramac river gravel, Missouri river sand, cylinder.
No. 13	1:5.43	15.58	1:5.80	14.71	4	Dolomitic limestone, Missouri river sand, cylinder.
No. 14	1:5.53	15.31	1:5.80	14.71	4	Dolomitic limestone, Missouri river sand, cylinder.
No. 15	1:5.43	15.58	1:5.80	14.71	4	Dolomitic limestone, Missouri river sand, cylinder.

The following table contains the results obtained in the analysis of a number of briquets composed of varying amounts of standard Ottawa sand and cement:

	Cement Found by SiO_2 Method		True Cement Content	
Serial Number	Per Cent	Mix	Per Cent	Mix
No. 0	23.62	1:3.23	23.36	1:3.28
No. 1	20.83	1:3.81	21.74	1:3.61
No. 2	20.51	1:3.87	21.02	1:3.76
No. 3	19.38	1:4.16	19.42	1:4.15

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[1] In Charge of Tests, France Stone Co. Laboratories, Toledo, Ohio.

SERIAL NUMBER	CEMENT FOUND BY SiO₂ METHOD PER CENT	MIX	TRUE CEMENT CONTENT PER CENT	MIX
No. 4	18.71	1:4.35	18.85	1:4.31
No. 5	16.95	1:4.90	16.32	1:5.13
No. 6	16.46	1:5.08	16.64	1:5.01
No. 6-A	16.82	1:4.95	16.73	1:4.98
No. 7	14.39	1:5.95	15.18	1:5.59
No. 8	13.56	1:6.38	14.36	1:5.96
No. 9	13.26	1:6.54	13.50	1:6.42
No. 10	12.19	1:7.20	12.38	1:7.08
No. 11	12.14	1:7.23	12.05	1:7.30

In each of the above analyses, four check samples were run.

CEMENT-INSOLUBLE RESIDUE

There is always a small portion of a cement sample determined as "insoluble matter" in the usual chemical analysis. Since the procedure described in the proposed tentative method does not expose the cement in the concrete to very rigorous solvent action, the percentage of the cement remaining out of the solution would be larger than the actual "insoluble matter." To ascertain just what amounts would resist solution, sixteen brands of cement at hand in the laboratory were run by the method used for concrete, the conditions being maintained as nearly the same as possible.

It will be seen in the following table that in all cases is the portion remaining out of solution less than 1 per cent, the average being 0.49 per cent. Since the amount of cement in concrete is usually from 12 to 25 per cent, the value of this insoluble matter in the cement falls to from 0.06 to 0.12 per cent for the entire concrete. In the analyses below, samples of approximately 5 g. were taken.

BRAND OF CEMENT	INSOLUBLE MATTER, PER CENT	BRAND OF CEMENT	INSOLUBLE MATTER, PER CENT	BRAND OF CEMENT	INSOLUBLE MATTER, PER CENT	BRAND OF CEMENT	INSOLUBLE MATTER, PER CENT
A	0.26	E	0.09	I	0.48	M	0.86
B	0.06	F	0.42	J	0.34	N	0.54
C	0.42	G	0.88	K	0.72	O	0.60
D	0.08	H	0.19	L	0.89	P	0.99

Average insoluble matter, all brands....0.49 per cent

SOLUBLE SILICA IN NATURAL MINERAL AGGREGATES

The reagents, hydrochloric acid and sodium hydroxide, which are used to liberate the silica from the calcium silicates will also attack the silica somewhat in its other forms. This action will be very slight because of the temperature employed and the time given the solvents.[1] To determine the effect of the reagents upon some representative siliceous materials, samples of Ottawa sand and Missouri River (Jefferson City) sand were prepared and treated as the concrete had been. It will be seen that the small error caused by the solution of some of the silica will be one of gain in the calculation of the cement content

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[1] For reference on silica solubility, see *Analytical Chemistry*, Treadwell-Hall, Vol. 1, p. 403.

TABLE I.—CEMENT CONTENT DETERMINATIONS OF CONCRETE MIXES.

Laboratory Control—(7 cu. ft. per batch)

Identification Number	Cement Found, per cent by weight of Dry Concrete				Calculated Cement Content, per cent	Strength in Terms of Averages[a]	Types of Aggregate[b]
	Determination 1	Determination 2	Determination 3	Average			
A4	13.88	14.05	.....	13.97	13.95	A	Gravel
A5	13.30	.....	.....	13.30	13.95	A	"
AA3B	16.06	15.75	15.88	15.70	15.91	A	"
AA4B	14.48	14.42	.....	14.45	15.91	A	"
AAA2-4B	15.64	.....	.....	15.64	13.95	P	Gravel[c]
AAA3-4B	14.84	15.26	14.92	15.01	13.95	M	"
AAA-5	14.10	.....	.....	14.10	13.95	M	"
AAA5B	15.30	15.54	15.15	15.33	13.95	A	"
B1	11.90	11.90	12.08	11.96	14.28	M	Dolomite
B2	13.33	13.15	13.00	13.16	14.28	A	"
B3	13.68	13.21	.....	13.45	14.28	M	"
B4	13.65	13.60	13.90	13.72	14.28	A	"
B5	13.29	13.00	13.54	13.28	14.28	A	"
B6	13.20	13.04	13.05	13.10	14.28	A	"
BB1B	15.22	15.32	15.07	15.20	16.24	M	"
BB2B	16.20	16.10	16.40	16.23	16.24	A	"
D3	13.85	14.43	.....	14.14	13.87	P	Gravel
D3B	14.20	14.37	.....	14.29	13.87	A	"
D5	9.92	9.55	10.00	9.82	13.87	M	"
D6	10.22	10.37	10.69	10.43	13.87	M	"
DD1	13.65	13.45	13.45	13.52	13.87	M	Gravel[c]
DD1B	14.28	14.32	14.10	14.23	13.87	A	"
DD2	12.36	12.50	.....	12.43	13.87	A	"
DD4	15.80	15.76	.....	15.78	13.87	P	"
DD6	13.10	12.94	.....	13.02	13.87	M	"
E2	11.88	11.81	.....	11.85	14.02	A	Gravel
E3	16.14	16.16	.....	16.15	14.02	A	"
E3B	13.90	14.17	14.18	14.08	14.02	A	"
E6	15.08	14.87	.....	14.98	14.02	A	"
EE4	15.95	15.72	.....	15.84	15.97	A	"
EE5	14.70	.....	.....	14.70	15.97	M	"
F2	15.10	14.96	15.06	15.04	14.13	P	Dolomite
F4B	14.41	14.65	14.52	14.53	14.13	A	"
F6	13.80	13.65	13.55	13.67	14.13	A	"
FF1	14.52	14.57	.....	14.55	14.13	A	Dolomite[c]
FF2	15.13	14.85	14.68	14.89	14.13	M	"
FF2B	13.75	13.50	13.61	13.62	14.13	M	"
II	13.65	13.78	13.90	13.78	14.13	A	Dolomite
14Ba	15.70	15.91	15.49	15.70	14.13	P	"
14Bb	14.02	13.62	14.12	13.92	14.13	A	"
IIIB	14.07	13.70	13.80	13.86	14.13	A	"
II4	13.54	13.48	13.31	13.44	14.13	P	"
II4B	13.50	.....	.....	13.50	14.13	A	Dolomite[c]
II5	11.63	11.66	.....	11.65	14.13	M	"
II5B	14.72	.....	.....	14.72	14.13	A	"
J2	13.48	13.84	.....	13.61	14.22	A	Dolomite
J4B	14.10	14.01	.....	14.06	14.22	A	"
J5	12.88	13.24	13.48	13.20	14.22	M	"
K3	15.54	15.76	15.71	15.67	14.51	A	"
K4	14.20	14.32	14.20	14.24	14.51	A	"
K4B	14.20	14.20	.....	14.20	14.51	A	"
K5	14.00	.....	.....	14.00	14.51	A	"
LLB	16.70	16.82	16.50	16.67	16.25	A	"
L4	12.60	12.85	12.73	16.25	16.25	M	"
LL2B	14.63	14.62	.....	14.63	14.84	A	"
M4B	16.25	.....	.....	16.25	16.22	A	"
M5B	14.60	.....	.....	14.60	16.22	A	"
MM2B	14.39	14.38	14.38	14.38	14.25	A	"
Known X	15.15	15.20	14.85	15.07	15.00		Bank Sand

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[a] A—Average strength plus or minus 10 per cent.
P—Average strength plus more than 10 per cent.
M—Average strength minus more than 10 per cent.

[b] The fine aggregates used were three bank sands from the Michigan territory except in the cases designated.

[c] Limestone sand was used as fine aggregate.

TABLE I.—(*Continued.*)

Identification Number	Cement Found, per cent by weight of Dry Concrete			Calculated Cement Content, per cent	Types of Aggregate[a]
	Determination 1	Determination 2	Average		
	MORTAR MIX				
W Mortar	16.15	16.23	16.19	16.15	Bank Sand
B Mortar	13.30	12.85	13.08	13.24	"
Black	27.50	27.80	27.65	27.50	"
White	21.60	21.20	21.40	21.50	"
	CONCRETE—FIELD SPECIMENS				
Eileen Road					
I21	14.90	14.90	14.90	Approximately 13.00 per cent Exact cement content unknown	Dolomite[b]
I22	15.65	15.95	15.80		
I23	14.61	14.75	14.63		
I24	13.48	13.60	13.54		
I25	14.80	14.57	14.69		
I26	11.68	11.59	11.64		
I27	14.30	14.44	14.37		
Hocking Valley					
A470	12.65	12.30	12.48	Approximately 12.00 per cent. Exact cement content unknown	Dolomite[c]
A588	9.75	9.45	9.60		
B690	9.95	10.09	10.02		
A6-127	13.20	13.45	13.33		
A6-129	16.28	16.72	16.50		

[a] The fine aggregates used were three bank sands from the Michigan territory except in the cases designated.
[b] Limestone sand was used as fine aggregate.
[c] Ohio bank sand.

and that it will therefore very nearly compensate the small error of loss caused by the insoluble matter in the cement:

OTTAWA SAND				AVERAGE
Sample weight, g	4.3116	5.0512	5.4455	
SiO_2 dissolved, per cent	0.12	0.13	0.11	0.12
MISSOURI RIVER SAND				
Sample weight, g	5.0796	5.1188	5.2530	
SiO_2 dissolved, per cent	0.13	0.13	0.15	0.14
Total average, per cent				0.13

This value will have to be reduced proportionately with the siliceous aggregate when applying it to concrete corrections. In case the corrections are not made, the error caused will be too small to enter seriously into the determination of the mix used.

During the past four years, this cement content determination has been used quite extensively in the France Stone Co. Laboratories to check the accuracy of batching concrete mixes as well as the segregation which occurs during the fabrication of test specimens. It was found that the strength irregularity in the specimens prepared under careful laboratory control could be accounted for in most cases by the difference in the cement content actually present in the specimens. The data given in Table I are the results obtained on such test specimens. In all cases the specimens analyzed for cement content were entire 6 by 12-in. compression cylinders or portions of the 6 by 6 by 44-in. transverse beams, including at least 3 in. of concrete on either side of the line of rupture.

The following table shows the percentages of soluble silica in certain mineral aggregates:

Aggregates		Soluble Silica, per cent	Aggregates		Soluble Silica, per cent
Silica	Dolomite	0.05	Limestone Sand	Dolomite	0.10
Huron Sand		0.12	Monroe	Dolomite	0.10
Waterville	Dolomite	0.12	Illinois Gravel		0.20
Bluffton	Dolomite	0.05	Illinois Sand		0.30
Holland	Dolomite	0.09	Middlepoint	Dolomite	0.07
Greenville	Gravel	0.30			

No effort was made in this investigation to determine the constituents of portland-cement concrete other than the amount of cement used. It should be noted however, that this method does give information as to the approximate analysis of the aggregate, that is, as to its carbonate and soluble parts or those siliceous and insoluble. Thus if the insoluble residue obtained is but a few per cent, the aggregates both coarse and fine, are calcareous or dolomitic material chiefly. If a mixture of cement, siliceous sand and limestone is used, the sand alone will remain as insoluble matter.

G. W. Burke describes a method for the "Estimation of the Constituents of Portland-Cement Concrete" (5). The plan involves a method of mechanical reduction and complete sieve analysis followed by chemical analyses of the sand-cement portions passing a ¼-in. mesh sieve. In this way both fine and coarse aggregates as well as cement are determined. There are dangers worthy of consideration, however, such as breaking down the more friable aggregates by the rubbing, the chance of adherence of the cement to the aggregate, and the disintegration of the mineral aggregates by ignition either through expansion stresses, by the decomposition of dolomite or by the expulsion of water. When one is not concerned with the separation of the aggregates and their estimation and only the cement content of a portland-cement concrete is desired, the purely chemical analysis which has been set forth in this Proposed Tentative Method[1] may be used with results fully as accurate, more quickly and easily obtained.

The method as presented does not apply to concrete specimens containing blast-furnace slag, diatomites, or sodium silicate, as these materials will also liberate silicic acid when treated with dilute acids and alkalies.

In an endeavor to learn with what success other chemists and engineers had used this test procedure, questionnaires were sent to men who were believed to be somewhat familiar with the method. The questions asked were as follows:

1. To what extent have you used this method?
2. Has it been satisfactory in all cases? In most cases?
3. If it has not been satisfactory, to what causes do you attribute this fact?
4. Have you any corrections or additions to make to the test procedure?

The following quotations are taken from the five replies which were received:

MR. A. KEITH LIGHT.[2]—I have used the method to quite an extent in determining the cement content of various portland-cement mortars and concretes; mostly those which have shown signs of disintegration shortly after being made. I have also checked the method many times with known mixtures of cement and various types of fine aggregate. I have found it quite satisfactory and to give accurate results, except when either diatomite or basic slags were used in the concrete.

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[1] See p. 763.

[2] Chemist, Testing Laboratories, Department of Public Works, Ottawa, Canada.

MR. F.V. REAGEL.[1]—We have used the method on three or four occasions to check the actual percentage of cement used in the arbitrary concrete mixes. In the past we have conducted some investigational work on the causes of scaling and in this investigation we used the method in analyzing the scale for its cement content.

Unless the actual precentage of silica in the cement has been previously determined it is hardly possible to expect to obtain the cement content within 1 per cent. However, when the actual silica content of the cement is actually known, the method is quite accurate. We believe the method is satisfactory where the approximate cement content is desired in hardened concrete.

MR. RAYMOND WILSON.[2]—We have used the method for the determination of the cement content of set portland-cement concrete and have found it generally to give good results. We consider it to be as accurate as any method so far published. For that reason and because of its simplicity, it is the standard method in our laboratory.

We have made a number of tests on concrete of known cement content and find that on mixtures of the order of richness of 1:5 the method gives values checking the known values within about 1 per cent by weight of the sample. Most of this work was done on concrete made with an argillaceous mestone aggregate.

A further series of tests on this subject seemed to indicate that results would be practically the same if only the acid treatment were used and the sodium hydroxide treatment were omitted. We tested a few cements and found that the amount of silica unattacked by the acid was of the order of a few tenths of one per cent. I think that it would be satisfactory in most cases to use the acid treatment only, possibly compensating for that by assuming a silica value in the cement of 21.5 per cent instead of the 21.75 per cent which is used in the method.

As a matter of precaution, we sometimes remove some of the aggregate by mechanical means and, after a thorough cleaning with acid, pulverize the aggregate and run a blank test for soluble silica. This, I believe, tends to make the accuracy and dependability of the analysis somewhat greater.

MR. C. H. LOVEJOY.[3]—We at one time analyzed a standard cement briquet, using this method, and obtained a fraction over 24 per cent of cement, whereas, the true result would be 25 per cent. We also analyzed an experimental cylinder, in which we knew the exact proportions, and the check was quite satisfactory.

In the chemical manipulation which is recommended we have made one or two slight changes. We only use 5 g. instead of 10 g., and run the sample in duplicate instead of in triplicate. We usually get good checks on our silica determination when care is used. I think the method is very satisfactory.

MR. L. G. CARMICK.[4]—I have used the method on only a few samples. Probably my experience with it has not been sufficient to justify any very strongly worded criticism. I have had it in mind to go further with it, but so far the pressure of other work has prevented.

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[1] Engineer of Materials, Missouri State Highway Dept., Jefferson City, Mo.

[2] Conservation Engineer, Portland Cement Assn., Chicago, Ill.

[3] Vice-President, The Forest City Testing Laboratory Co., Cleveland, Ohio.

[4] Associate Chemist, U. S. Dept. of Agriculture, Bureau of Public Roads, Washington, D. C.

The weak points as I see them are these: first, we seldom know the true silica content of the cement, it may easily be 1 or 2 per cent either side of the assumed value, and second, silica is a minor constituent being, roughly, one fifth of the cement, and as this method depends wholly on the silica determination a small error may have a large effect.

Since Mr. Carmick's letter was the only one which stated specific criticisms, the author makes the following reply to these criticisms:

Regarding the criticisms of Mr. Carmick, they are both good and obvious, being the first considered while the author was working on the method seven years ago. It is true that the silica content of cement used in a specimen of concrete may occasionally not be known and an average value must be assumed. However, in very many instances, whether in field work or in laboratory research, that factor is known or can be determined with little effort. Assuming, however, that the silica content of the cement is not known and we are forced to take the average value of 21.75 per cent, a variation of 1 per cent as Mr. Carmick suggests, above or below this assumed value, will mean a variation of only 5 per cent in the cement content of the concrete—a difference of three-tenths of a bag of cement per a six-sack batch of concrete. There is plenty of concrete poured, as you know, in which the actual cement content is not controlled closer than that value. The author feels, however, that this criticism is not directed at the method itself since it applies to conditions under which the method should or should not be used rather than to the accuracy of the procedure itself.

Mr. Carmick's second criticism, namely, that of silica being a minor constituent and hence a small error in the determination which introduces considerable error in the cement content, is more specifically a criticism of the test procedure. Before this scheme of analysis was released six years ago, its reliability was found satisfactory as determined by numerous quadruplicate tests on the same samples. It was found that results within ± 0.2 per cent SiO_2 could be obtained by observing the precautions called for in the procedure. This would involve a variation of only 1 per cent in true cement content which is obviously a small variation. Careful examination of supposedly uniform concrete specimens under controlled laboratory conditions showed that segregation of the materials during placing introduces variations much larger than 1 per cent. If the method is accurate within the limits of placing of constituents in a test sample, the author feels it justifies recognition. In fact, we have come to use this method as a routine check on our concrete specimens made for research purposes, to check the uniformity of our mixes with the several produced from any one batch or like batches. In most cases the difference in the strength can be accounted for by a difference in the cement content of the individual specimens.

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(1) H. Hart, *Tonindustrie Zeitung*, Vol. 24, p. 188 (1900).

(2) Jordis and Kanteb, *Zeitschrift für anorganische Chemie*, Vol. 35, p. 16 (1903).

(3) Richter, *Tonindustrie Zeitung*, Vol. 29, p. 422 (1905).

(4) Kühl and Knote, *Chemie des hyd. Bindemittel*, p. 314, Leipzig (1915).

(5) G. W. Burke, "Estimation of the Constituents of Portland Cement Concrete," *Bulletin 61*, Iowa Engineering Experiment Station (1923); abstracted in *Chemical Abstracts*, Vol. 18, p. 1891 (1924).

The results of studies are presented, the object of which was to devise a method by which the amount of the various materials used in concrete can be determined without having samples of the original materials at hand. For great accuracy it is necessary to have samples of the original materials. Where these are not available, the SiO_2 and CaO contents of the cement must be chosen for average values of the combined product, this being considered a reliable procedure. The presence of a large amount of finely divided clay, silt, or vegetable matter in the sand will have a tendency to vitiate the results if based on the SiO_2 method alone. This, however, is not so true of the CaO basis method, as poor sand does not seem to affect the results. The dehydration method served as an accurate means for determining the weight of the original materials and to make possible an accurate separation of stone and of a sample of sand for analysis. The SiO_2 content of sand-cement mixtures of samples of similar mix was not so uniform as the CaO content. It is considered probable that either method may be used satisfactorily on samples made from a good grade of sand but that for samples containing a poor grade of sand the CaO basis method will give the more reliable results. **(H. G.)**

(6) A. Landini, "Analysis of Cement Conglomerates," *Chimie et Industrie*, Vol. 11, p. 929 (1924); abstracted in *Chemical Abstracts*, Vol. 18, p. 2590 (1924).

The analysis of concrete to determine the proportions of the various ingredients is extremely difficult to carry out because it is almost impossible to get a representative sample when ingredients of various sizes have been used; the sand and gravel contain some $CaCO_3$ and some acid-soluble constituents; cement contains a considerable percentage of acid-insoluble material. In special cases, especially when the composition of the sand and gravel is known, the amount of cement can be obtained from the determination of the soluble SiO_2. (A. Papineau-Couture.)

(7) H. F. Kriege, "Determining the Cement Content of Concrete," *Engineering News-Record*, Vol. 92, p. 892 (1924); abstracted in *Chemical Abstracts*, Vol. 18, p. 2231 (1924).

While cement and the common aggregates used in making concrete contain SiO_2 and a number of other compounds in common, there is an essential difference in the state of combination of the SiO_2. It is, therefore, possible to treat a sample of finely ground concrete with an acid which will liberate the SiO_2 from the silicates contained in the cement and not attack the silicates in the aggregates. The method is as follows: Crush a 10-lb. sample to ½-in. size, quarter down, and put 100 g. through a 150 or 200-mesh sieve. Weigh three or four 10-g. portions into a 250-cc. beaker, treat with 100 cc. of 3.3 *N* HCl and stir thoroughly. Allow to settle, decant through an ignited and weighed Gooch crucible, retaining as much of the residue as possible, and wash by decantation twice with hot H_2O. Add 75 cc. of *N* NaOH solution to the residue, stir, and heat to 75° C. Decant as before and wash twice with hot H_2O. Transfer the residue to the crucible and wash with at least 60 cc. of hot H_2O. Evaporate the filtrate (which contains the SiO_2 originally present in the cement) to dryness and determine the SiO_2 in the regular way, moistening with HCl, dehydrating, and finally volatilizing in the presence of H_2SO_4 and HF. By taking the average SiO_2 in cement as 22.75 per cent, the per cent of cement in the concrete sample may be easily calculated. Fifteen samples of concrete of known composition were analyzed by this method and the error did not exceed 1 per cent. (J. C. Witt.)

[NOTE.—The SiO_2 content factor is here given erroneously as 22.75 per cent instead of 21.75 per cent.]

(8) O. Frey, "Soluble Silica as a Means of Works Control," *Tonindustrie Zeitung*, Vol. 49, p. 337 (1925); abstracted in *Transactions*, Ceramic Soc. (English), Vol. 24, p. 56 (1924–1925).

A method is described by which the determination of the soluble SiO_2, which plays an important part in the hardening process of cement may be utilized to control the quality of the output.

Additional abstract (previously unpublished).—Soluable silica plays an important role in the hardening processes of cement. Also it serves as an indicator of the extent to which clinker has been burned, since properly burned clinker contains all but traces of its SiO_2 in a form readily decomposable and rendered soluble by acid treatment. Place 2 g. of powdered clinker ground to approximately 200-mesh size, in a 400-cc. porcelain dish and moisten with a stream of H_2O (50 cc.) to prevent lumping. Add 150 cc. of boiling HCl (1:3). Heat for 2 minutes and decant while boiling hot through a 11-cm. filter paper. Cover the residue with HCl (1:3), boil 5 minutes and decant through the same filter paper. Repeat until the solution is no longer yellow. Boil and decant the residue two or three times with 5 per cent NaOH solution, and wash three times with H_2O by decantation. Transfer the residue to the filter, ignite and weigh as insoluble silica. The value subtracted from the total SiO_2 gives the soluble silica present in the clinker. Very good results are claimed for this method from the chemical standpoint and as a means of measuring the degrees of clinker burning.

Abstractor's Note.—This procedure is very similar to the method proposed by Kriege (7), both as to plan and technic, although no statement is made concerning this method which appeared a year previous. (H. F. Kriege.)

(9) E. E. Butterfield, "Analytical Properties of Set and Hardened Mortars," *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part II, p. 283 (1925); abstracted in *Chemical Abstracts*, Vol. 19, p. 2870 (1925).

The cement content may be calculated from the determination of the CaO in mortars proportioned by the method of mortar voids or with inundated sand with an average variation of 1 per cent. In other samples the variation between cement used and cement found was 15 per cent. (J. C. Witt.)

(10) Domenico Meneghini, "Determination of the Quantity of Cement Used in Hydraulic Concretes," *Annail*, Scuola Ing., Padova 2, p. 95 (1926); abstracted in *Chemical Abstracts*, Vol. 22, p. 3276 (1928).

Finely pulverize a weighed sample (1 to 2 g. for cement; 10 g. for cement mixtures) and treat with 250 to 300 cc. of boiling H_2O. Add 100 cc. of HCl (density 1.05 to 1.06) and after the liberation of CO_2 has ceased heat the mixture but do not allow to boil, wash by decantation with boiling H_2O and filter the washings through a Gooch crucible. Treat the residue with about 75 cc. of *N* NaOH on the water bath at 80° C. Decant this alkaline liquor into the same filter previously used and wash the residue thoroughly with hot H_2O. The filtrate contains all the active SiO_2 derived from the silicates that are attacked by this treatment. The SiO_2 is separated and weighed as SiO_2 and represents the so-called active SiO_2. The method was controlled by determining the active SiO_2 in fresh cement and in cement mixtures prepared under various conditions and allowed to stand for various lengths of time. (L. T. Fairhall.)

(11) Daniel Florentin, *Comptes rendus*, Vol. 183, p. 53 (1926).

(12) H. Le Chatelier, *Comptes rendus*, Vol. 102, p. 1243.

(13) J. L. Heitzman, "Procedure for Analysis of Mortars," *Engineering News-Record*, Vol. 97, p. 271 (1926); abstracted in *Chemical Abstracts*, Vol. 20, p. 3791 (1926).

Weigh 1 g. of crushed and dried sample, add 500 cc. of dilute HCl (1:9) and boil until all the soluble matter is in solution. Filter, ignite, and weigh. This weight times $\frac{100}{95}$ equals sand content. Evaporate the filtrate to dryness, cool, add 200 cc. dilute HCl (1:1), warm until Fe salts are in solution and then add 50 cc. distilled H_2O. After boiling, filter, ignite, and weigh. This weight times 500 equals approximate percentage of portland cement. Dirty sand would introduce an error in this calculation. Determine CaO and MgO in the filtrate in the usual manner. Calculate the CaO and MgO in the cement by multiplying the latter by 0.625 and 0.032 respectively, and subtract these amounts from the total CaO and MgO found. The combined remaining CaO and MgO times $\frac{100}{95}$ equals approximate percentage of lime. (R. E. Thompson.)

(14) Daniel Florentin, "On the Determination of Soluble Silica in Cements, Mortars and Concrete," *Comptes rendus*, No. 12, p. 621 (1926).

One gram of cement is added in small portions to 50 to 60 cc. cold HCl (sp. gr. 1.12). Chill, filter, wash the residue with a warm 5 to 6-per-cent Na_2CO_3 solution. Determine the SiO_2 in the filtrate in the usual way. The cement is calculated by dividing the SiO_2 content by 20 to 21 per cent. (H. F. Kriege.)

(15) G. Gallo, "The Determination of Cement in Hydraulic Mixtures," *Giornale di Chimica Industria ed Applicationes*, Vol. 9, p. 313 (1927).

The discussion includes the results of tests on three concrete specimens of known cement content analyzed by Kriege's method (7) for the soluble silica and by Gallo's ammonium chloride method for soluble calcium oxide after ignition of the sample. The former procedure gave rather uniformly high results, probably due to the presence of easily decomposable silicates in the sand and gravel. The results by the latter method were more varied and below the true cement content but closer to it than in the former case. (H. F. Kriege.)

(16) D. Meneghini, "Lettere Alla Redazione," *Giornale di Chimica Industria ed Applicationes*, Vol. 9, p. 54 (1927).

Meneghini answers the claim of Florentin (14) to priority with a method of analyzing concrete for cement content by means of dilute HCl by referring to Kriege's method (7). Attention is called to the irregular behavior with pozzuolana cements. (H. F. Kreige.)

(17) J. L. Heitzman, "Procedure for the Analysis of Cinder Concrete," *Concrete*, Vol. 32, p. 46, June, 1928.

A 5 to 10-lb. sample is crushed to pass ½-in. sieve.

Cement.—A portion obtained by quartering is pulverized. Weigh 1-g. sample of the pulverized specimen into a beaker, add 30 to 50 cc. of HCl (1:9), warm on a hot plate until all soluble matter is dissolved, filter, and wash well with small amounts of H_2O. Dry the filter paper and residue to constant weight at 100° C. Transfer by brushing to a balance pan and weigh, disregarding the small amounts adhering to the paper. Multiply the weight of insoluble matter by 100 to obtain the percentage of sand and cinders in the concrete. Evaporate the filtrate to complete dryness, cool, add 20 cc. of HCl (1:1), warm, dilute to 50 cc. with H_2O, heat to boiling, filter, wash thoroughly, ignite and weigh. This soluble silica content multiplied by 500 gives the percentage of cement in the sample.

Sand and Cinders.—A 50-g. sample of the specimen crushed to pass ¼-in. sieve is treated with 100 cc. of HCl. Warm until solution is complete, filter, wash twice by decantation and finally on the filter. Discard the filtrate. Transfer the drained residue to an evaporating dish and separate the cinders from the sand by elutriation with Thoulet's solution. (240-g. mercuric iodide plus 200-g. potassium iodide plus 150-cc. water.) Best results are obtained by covering the aggregate mixture with the solution, stirring for 15 seconds, allowing 15 seconds for settling, and pouring off the floating cinders into another container. When the separation is complete, wash each aggregate by decantation, dry to constant weight, weigh and calculate to percentage by weight. To convert to the volume basis, assume 45 lb. per cu. ft. for the cinders and 94 lb. for the cement and the sand. (H. F. Kriege.)

(18) V. Rodt, "Determination of the Mechanical Mixture of Mortar and Concrete. Ratio of Cement to Aggregate in the Mix," *Zement*, Vol. 17, p. 138 (1928); abstracted in *Chemical Abstracts*, Vol. 22, p. 3274 (1928).

In a discussion of previous German methods of determining the cement content of concrete it is claimed that an error is introduced by the liberation of soluble or colloidal SiO_2 from parts of the aggregate as well as from the cement. In sands this soluble SiO_2 is derived chiefly from the silt or loam. This effect may be reduced by diluting the 1:3 HCl solution to 1:9 whereby the soluble SiO_2 liberated is less than 0.1 per cent. The procedure is as follows: digest 10 g. of finely-ground sample with 100 cc. of 1:9 HCl on the H_2O bath, boil for 2 minutes, filter at once and wash the residue off into a beaker with 100 cc. of 5-per-cent Na_2CO_3 solution and boil for 2 minutes. Filter, combine the filtrates and determine the SiO_2 liberated by the usual methods. If the silt content is known to be small 1:3 HCl digestion may be employed. The SiO_2 found is calculated to cement by using 22 per cent as the SiO_2 content of cement. Since the H_2O of hydration is about 20 per cent of the set cement weight this correction must be added if the percentage composition of the concrete is to be stated in terms of the hydrated cement. (H. F. Kriege.)

(19) L. G. Carmick, "The Determination of the Proportions of Constituents in Concrete," *Public Roads*, Bureau of Mines, Vol. 9, p. 88 (1928); abstracted in *Chemical Abstracts*, Vol. 22, p. 3970 (1928).

The proportions of cement, sand and stone in concrete are calculated from chemical analysis. (L. B. Miller.)

(20) Heinrich Hart, "Determination of the Mix of Concrete," *Zement*, Vol. 17, p. 319 (1928); abstracted in *Chemical Abstracts*, Vol. 22, p. 3275 (1928).

Referring to Rodt's article **(18)** it is claimed that the method described is limited to quartz sand-gravel concrete whereas in practice the aggregates vary so greatly in composition that the method will not apply generally. (H. F. Kriege.)

(21) Report of Subcommittee I on Definitions and Chemical Limitations of Committee C-1 on Cement, ***Proceedings***, Am. Soc. Testing Mats., Vol. 28, Part I, pp. 238–243, particularly p. 242 (1928).

(22) G. Baire, "Determination of Soluble Silica in Pozzuolana Cements," *Chimie et Industrie*, Special Number, March, 1930, p. 298; abstracted in *Chemical Abstracts*, Vol. 24, p. 5453 (1930).

The usual method for the determination of soluble SiO_2 in portland cements (solution in HCl under definite conditions) gives low results with pozzuolana cements either alone or in admixture with portland cement, because of incomplete decomposition and solution of silicates which are enclosed in SiO_2 insoluble in acids. The Florentin method (*Chemical Abstracts*, Vol. 20, p. 3069 (1926)) also gives low results. The Cayeux method (treatment of the sample with cold 20-per-cent KOH for 20 hours and then for 4 hours at 50 to 65° C.) gives good results with straight pozzuolana, but not with mixtures containing portland cement because the silicates are incompletely decomposed. For mixed pozzuolana-portland cements Baire proposes combining the two methods as follows: treat 1 g. of sample with 100 cc. H_2O, add 25 cc. 1:1 HCl while stirring, rapidly heat till the solution is light yellow, filter immediately through an ashless filter, wash 6 times with boiling water, wash the precipitate into an evaporating dish, incinerate the filter and add to the precipitate, dry almost completely, add 100 cc. of 20-per-cent KOH (density 1.177), let stand 20 hours with occasional stirring, keep 4 hours at 50 to 65° C., decant the solution, washing 4 or 5 times with cold water by decantation, filter, wash 5 times with boiling dilute HCl (1:9) and finally 7 or 8 times with boiling water; let the decanted solution and decanted washings stand several hours, decant the clear solution, filter the precipitate and wash as above, ignite the 2 filters, fuse with Na_2CO_3 plus K_2CO_3 and determine SiO_2 in the melt, giving insoluble SiO_2 in the sample. Soluble SiO_2 is obtained by difference from the total SiO_2. (A. Papineau-Couture.)

(23) J. L. Heitzman, "Analysis of Complicated Concrete Mixes," *Rock Products*, Vol. 33, No. 23, p. 62 (1930); abstracted in *Chemical Abstracts*, Vol. 25, p. 184 (1931).

The methods outlined are designed to cover the determination of the cement content and the properties of aggregates used in concrete containing sand, cinders, slag and natural aggregates. The cement content is found by digesting portions of the pulverized sample with warm HCl (10-per-cent), filtering, washing, and determining the silica in the filtrate in the usual way. The insoluble fine and coarse aggregates are separated by elutriation with Thoulet's solution if sufficient difference in specific gravity occurs. Otherwise, the original concrete must be broken up by heating, quenching, rubbing or gentle grinding as outlined by Burke (5). In specimens observed to contain slag, some of this constituent must be removed from the concrete and analyzed separately. Knowing the soluble silica or lime in the cement (A), the slag (B) and the mixture (C), the percentage of slag in a 100-per-cent mixture of cement and slag is as follows:

$$X = 100 \frac{A - C}{A - B}$$

The presence of cinders in the concrete is verified in the insoluble residue by the occurrence of coke or unburned coal. Physical and chemical characteristics of the coarse aggregates should be determined on pieces obtained from the concrete mass by thermal disintegration and quenching. (H. F. Kriege.)

NOTE.—These procedures are the same method of determining the cement content outlined by Kriege (7) except for several refinements suggested by him. Even so, accuracy sufficient to be upheld in the courts is obtained.

(24) A. K. Light, "Determination of Cement Content of Concrete," *Journal.* Soc. Chemical Industry, Vol. 49, p. 77 T (1930); abstracted in *Chemical Abstracts*, Vol. 24, p. 1953 (1930).

Moisten 10 g. of 100-mesh sample with hot water, and stir to prevent lumping, Add slowly, while stirring, 100 cc. of 1:3 HCl. Allow to settle after effervescence ceases. Decant through a Gooch crucible. Wash the residue in the beaker twice with hot water by decantation. Add 75 cc. of a 4-per-cent NaOH solution to the residue and heat to 75 to 80° C., stirring constantly for 10 to 15 minutes, then allow to settle. Filter and wash by decantation through the same Gooch crucible into the previous acid filtrate. Transfer all of the residue to the Gooch crucible and wash thoroughly with hot water. Evaporate the solution to dryness, bake, moisten with concentrated HCl and bake again. Take up with 75 cc. of 1:4 HCl and boil to dissolve all soluble matter. Filter, wash with dilute HCl and hot water, ignite the residue in a platinum crucible and weigh. Moisten with concentrated H_2SO_4, add 10 to 15 cc. of HF and again evaporate, ignite and weigh. The loss is SiO_2 liberated from cement. Divide by 0.215 to obtain percentage of cement in concrete. (H. C. Parish.)

(25) A. K. Light, "Checking up on the Concrete Mix," *Contract Record and Engineering Review*, Vol. 44, p. 1048 (1930); abstracted in *Chemical Abstracts*, Vol. 24, p. 5962 (1930).

The methods of Burke (5) and of Kriege (7) for determining the composition of concrete are described and their limitations discussed. In the former the constituents are physically separated after heating the specimen in a muffle at 600 to 700° C., while the latter is based on the difference in the state of combination of the Si in the cement and in the aggregate, the Ca silicates of the cement being analytically separated from the SiO_2 and Al silicates of the aggregate. The mix employed in the making of a specimen of concrete may be fairly closely estimated by a combination of these methods. (E. R. Thompson.)

26) A. K. Light, "Determining the Constituents of Hardened Concrete," *Concrete*, Vol. 37, No. 4, p. 35, October, 1930.

APPENDIX VII

THE EFFECT OF AGGREGATE AND OTHER VARIABLES ON THE ELASTIC PROPERTIES OF CONCRETE

By P. M. Noble[1]

Introduction

In most of the state of Kansas as well as adjoining states, there is a lack of material suitable for use as coarse aggregate in concrete. In many of these localities, however, there is an abundance of sand and sand-gravel in stream beds and pit deposits. At the present time considerable quantities of this type of material are being used as "total" aggregate in concrete construction. Very little information is available concerning the elastic properties of concrete made with this type of aggregate. Earlier investigators have used mixed aggregates almost entirely. This investigation was instituted to obtain information on the elastic properties of sand-gravel concrete in particular, and also to determine the effects of various types of coarse aggregates on these properties.

Other variables studied, include the condition of loading, fineness modulus, richness of mix, water-cement ratio, age at test, moisture content and ultimate strength.

This work has been conducted by the Engineering Experiment Station of the Kansas State College at Manhattan, Kans. The work has been under the direction of C. H. Scholer, Professor of Applied Mechanics and Engineer of Tests.

Materials

The tests are divided into two groups depending upon the type of aggregate used. In the first group all specimens are of sand-gravel concrete and in the second group mixed aggregate concrete.

Sand-Gravel.—This aggregate is a clean, hard, siliceous sand-gravel of glacial origin obtained from alluvial deposits in northern Kansas. The material has a fineness modulus of about 3.50 as it comes from the pit. Practically all of this material will pass a ¾-in. mesh sieve, and from 4 to 8 per cent is retained on the ⅜-in. mesh sieve. All of this material was screened over the No. 28 sieve and the two portions recombined to obtain the desired fineness modulus for each series of specimens.

Data are reported for the sand-gravel group of specimens covering the effect of the following variables on the elastic properties:

Condition of loading;
Fineness modulus (varying from 3.5 to 4.4);
Richness of mix (varying from 1:3 to 1:5);
Water-cement ratio (varying from 0.6 to 0.9);
Age at test (varying from 14 days to 1 year);
Moisture content; and
Compressive strength.

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Mixed Aggregate.—Kansas River sand obtained at Manhattan, Kans., was used as fine aggregate for the mixed aggregate specimens in the second group. This is a clean, granitic sand having a fineness modulus of about 2.75.

The coarse aggregates used in this group of specimens were as follows:

1. Local limestone from a quarry near Manhattan, Kans.; a soft, white limestone. This stone is not recommended for use in concrete because of slight indications of unsoundness.
2. Moline limestone from quarries near Moline, Kans.; a fairly dense gray limestone used extensively in Eastern Kansas as a coarse aggregate, but requires close inspection to avoid shale and unsound material.
3. Lincoln sandstone from Lincoln County, Kans.; a gray sandstone of superior quality consisting of a siliceous sand cemented with calcium carbonate.
4. Joplin flint obtained from Cherokee County, Kans.; a chert obtained as a by-product of the lead and zinc industry in Southeastern Kansas. This material is used quite extensively as coarse aggregate in this district.
5. Silverdale gravel, a hard, flinty gravel obtained from alluvial deposits in Cowley County, Kans.

The coarse aggregate was screened over the ¾, ⅜-in. and No. 4 sieves, and recombined in the following proportions:

SIEVE OPENING	PERCENTAGE RETAINED
¾-in	50
⅜-in	80
No. 4	100
Fineness Modulus	7.30

Data are reported for the following variables in this group:

Type of aggregate;
Water-cement ratio;
Age at test;
Compressive strength.

The gradation and mix were constant for this group.

Cement.—The cement used was a standard brand of portland cement. Sufficient cement was obtained at one time to make all of the specimens, and was thoroughly mixed in a concrete mixer and stored in air-tight galvanized cans until it was used. Water was used from the college supply obtained from wells.

PROPORTIONING AND MIXING

All mixes are expressed by dry and rodded volumes. Mixes for the sand-gravel specimens are expressed as one volume of cement to a given number of volumes of sand-gravel or "total aggregate," and vary from 1:3 to 1:5. All of the mixed aggregate specimens are made with a 1:1¾:3½ mix. The weight of cement was assumed to be 94 lb. per cu. ft.

The amount of mixing water is expressed as the ratio of the volumes of water and cement. In making the sand-gravel specimens, allowance for absorption and evaporation was made by adding water in the amount of 0.5 per cent of the weight of the aggregate. For the mixed aggregate specimens this allowance was taken care of by soaking the coarse aggregate for several hours and surface-drying before using.

Mixing was done in a barrel mixer which ran at about 18 r.p.m. The dry materials were thoroughly mixed before the water was added. Mixing was continued after the water was added until all material appeared to be well mixed, about 1½ to 2 minutes.

TABLE I.—DATA ON SPECIMENS OF SAND-GRAVEL.

Test Series Number	Fineness Modulus	Mix by Volume	Water-Cement Ratio	Slump, in.	Cement Factor, barrels per cu. yd.	28-day Compressive Strength, 3 by 6-in. Cylinder, lb. per sq. in.	Modulus of Elasticity, E, lb. per sq. in.				Poisson's Ratio			
							14 days	28 days	56 days	112 days	14 days	28 days	56 days	112 days
537	3.5	1:3	0.7	3.00	1.89	3458	3 509 000	3 512 000	3 649 000	3 970 000	0.182	0.204	0.176	0.216
837	3.8	1:3	0.7	5.75	1.90	3768	3 356 000	3 614 000	3 881 000	4 240 000	0.164	0.184	....	0.206
137	4.1	1:3	0.7	7.50	1.85	3925	3 247 000	3 538 000	3 897 000	3 873 000	0.159	0.194	0.204	0.213
437	4.4	1:3	0.7	8.50	1.89	3982	3 344 000	3 674 000	3 973 000	3 940 000	0.171	0.174	0.205	0.198
5357	3.5	1:3.5	0.7	1.00	1.70	3722	3 509 000	3 964 000	3 984 000	3 868 000	0.204	0.199	0.173	0.198
8357	3.8	1:3.5	0.7	1.25	1.70	3763	3 356 000	3 576 000	3 979 000	4 158 000	0.188	0.137	0.180	0.213
546	3.5	1:4	0.6	0.25	1.45	2933	3 135 000	3 357 000	3 788 000	3 678 000	0.222	0.180	0.234	0.204
146	4.1	1:4	0.6	0.25	1.48	1937	3 348 000	4 027 000	4 244 000	4 294 000	0.155	0.190	0.193	0.207
547	3.5	1:4	0.7	0.25	1.46	3052	3 401 000	3 436 000	3 498 000	3 775 000	0.197	0.215	....	0.195
847	3.8	1:4	0.7	0.50	1.56	3309	3 311 000	3 627 000	3 899 000	3 882 000	0.192	0.192	0.225	0.162
147	4.1	1:4	0.7	1.00	1.52	2948	3 509 000	3 886 000	3 960 000	3 970 000	0.183	0.182	0.187	0.207
447	4.4	1:4	0.7	1.50	1.51	4080	3 846 000	4 027 000	4 318 000	4 242 000	0.196	0.158	0.205	0.194
548	3.5	1:4	0.8	1.25	1.51	2946	3 086 000	3 441 000	3 644 000	3 736 000	0.164	0.174	0.196	0.177
148	4.1	1:4	0.8	4.75	1.48	3354	3 145 000	3 438 000	3 988 000	3 842 000	0.179	0.184	0.183	0.219
549	3.5	1:4	0.9	7.50	1.42	2604	2 326 000	2 608 000	2 814 000	2 685 000	0.198	....	0.204	0.198
149	4.1	1:4	0.9	7.50	1.47	2982	2 597 000	3 181 000	3 394 000	3 567 000	0.167	....	0.176	0.192
1457	4.1	1:4.5	0.7	0.00	1.45	2581	2 882 000	3 003 000	3 473 000	3 403 000	0.211	0.180	0.216	0.255
4457	4.4	1:4.5	0.7	0.50	1.38	3038	3 356 000	....	4 017 000	3 953 000	0.144	....	0.212	0.193
857	3.8	1:5	0.7	0.00	1.23	2006	1 934 000	2 165 000	2 582 000	2 394 000	0.400	0.306	0.319	0.303
157	4.1	1:5	0.7	0.00	1.20	2228	2 381 000	3 049 000	3 110 000	3 108 000	0.166	0.182	0.215	0.214
457	4.4	1:5	0.7	0.25	1.22	3406	3 145 000	3 607 000	4 075 000	4 069 000	0.173	0.181	0.209	0.194

TABLE II.—DATA ON SPECIMENS OF MIXED AGGREGATE.

Test Series Number	Coarse Aggregate	Water-Cement Ratio	Slump, in.	Cement Factor, barrels per cu. yd.	28-day Compressive Strength, 3 by 6-in. Cylinders, lb. per sq. in.	Modulus of Elasticity, E, lb. per sq. in.			Poisson's Ratio		
						14 days	28 days	56 days	14 days	28 days	56 days
L 6.....	Local Limestone..	0.6	0.00	1.46	3738	3 573 000	3 548 000	3 806 000	0.213	0.184	0.210
L 7.....		0.7	1.50	1.53	4058	3 764 000	3 781 000	4 054 000	0.190	0.197	0.212
L 9.....		0.9	7.50	1.51	2088	2 570 000	2 889 000	3 440 000	0.164	0.210	0.219
M 6....	Moline Limestone..	0.6	0.25	1.57	4645	4 292 000	4 720 000	4 920 000	0.230	0.195	0.185
M 7....		0.7	1.75	1.58	4402	4 154 000	4 610 000	5 133 000	0.166	0.176	0.208
M 9....		0.9	8.00	1.54	1936	3 649 000	4 070 000	4 492 000	0.200	0.198	0.192
S 6.....	Lincoln Sandstone..	0.6	0.25	1.52	4049	4 447 000	4 895 000	5 368 000	0.138	0.180	0.203
S 7.....		0.7	1.25	1.50	3938	4 437 000	5 058 000	5 273 000	0.158	0.178	0.205
S 9.....		0.9	6.00	1.48	2437	3 776 000	4 306 000	4 636 000	0.176	0.187	0.164
F 6.....	Joplin Flint...	0.6	0.00	1.45	4188	5 572 000	5 694 000	6 546 000	0.164	0.169	0.201
F 7.....		0.7	1.50	1.47	3057	5 334 000	6 090 000	6 764 000	0.142	0.167	0.166
F 9.....		0.9	7.00	1.44	2436	4 417 000	5 698 000	6 045 000	0.121	0.224	0.167
G 6.....	Silverdale Gravel.	0.6	0.50	1.45	4143	5 990 000	6 347 000	6 531 000	0.111	0.198	0.161
G 7.....		0.7	2.25	1.45	3085	4 960 000	5 368 000	5 935 000	0.166	0.180	0.166
G 9.....		0.9	7.00	1.42	2895	4 619 000	5 321 000	5 867 000	0.234	0.192	0.155

The slump, flow and weight per cubic foot were obtained for the concrete before the specimens were made.

The weight per cubic foot for the concrete was obtained in the same manner as for the dry aggregate.

Consistency tests for slump and flow were made in accordance with the usually accepted methods.

Data for slump, cement factor and 28-day compressive strengths are given in Tables I and II.

TEST SPECIMENS

Each series of specimens in the sand-gravel group consisted of five 6 by 12-in. cylinders for determining the elastic properties, and three 3 by 6-in. cylinders for determining the 28-day compressive strength of the concrete. For the mixed aggregate group, each series consisted of four 6 by 12-in. cylinders, and six 3 by 6-in. cylinders for determining the 28 and 56-day compressive strengths of the concrete. All of the specimens in a single series were made in one batch, the batch being about 1.1 cu. ft.

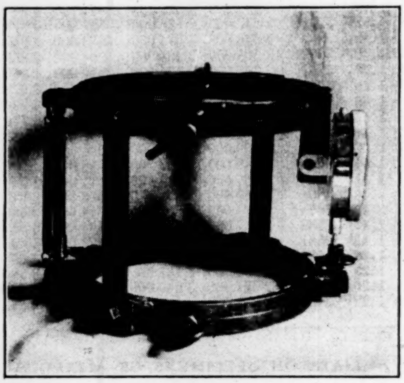

FIG. 1.—Axial Compressometer (side view).

In general, the 6 by 12-in. cylinders were made in steel molds. Some of the earlier series were made in machined cast-aluminum molds. The specimens made in these molds showed considerable discoloration and pitting of the surface in contact with the aluminum. While it was not definitely decided that there was any injurious effect on the concrete, the use of these molds was discontinued and steel molds substituted. The molds were placed on machined cast-iron base plates which gave the bottom of the cylinders a comparatively smooth surface. The concrete was rodded in the same manner as that used for determining the weight per cubic foot of aggregate. All molds and plates were greased before using.

The 3 by 6-in. strength specimens were made in cylindrical steel molds using 4 by 4-in. glass base plates. The concrete was tamped in these molds by means of a 1-in. round tamping rod having a flat surface at the lower end.

All specimens were removed from the molds the day after they were made and were stored in a "moist room" until the day they were to be tested.

DESCRIPTION OF STRAINOMETERS

Since there were no strainometers in the laboratory suitable for making the delicate measurements for determining the elastic properties of concrete cylinders, it was necessary to develop such instruments. A review of the various types of instruments used by other investigators was made in an effort to determine which type would best suit the needs of the proposed tests.

As a result of this study two strainometers were designed and built in the college shops. These strainometers are similar to those used by Mr. H. J. Gilkey at the University of Colorado,[1] and by Mr. Stanton Walker at the Structural Materials Research Laboratory.[2]

Axial Compressometer.—Details of the longitudinal or axial compressometer are shown in Fig. 1. This instrument is of the five-point clamp type. Three conical pointed set-screws at intervals of 120 deg. hold the lower ring rigidly in place on the specimen. The upper ring, to which the dial is rigidly attached, has only two set-screws which are diametrically opposite permitting the ring to rotate. The spindle of the dial rests against a rod which is rigidly attached to the lower ring. The hinged joint while maintaining a constant distance of 6 in. between the two rings at the back, permits the upper ring to rotate with the deformation of the specimen. The deformation as indicated on the dial then is twice the actual deformation of the specimen within the 6-in. gage length since the distance from the joint to the spindle is twice the distance from the joint to the set-screws in the upper ring.

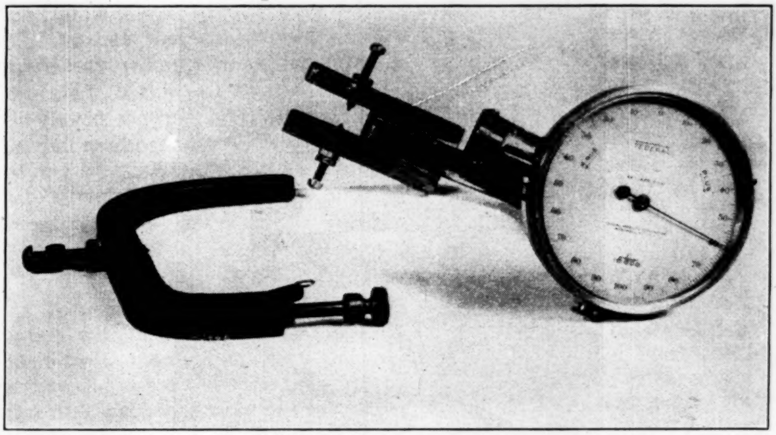

FIG. 2.—Radial Extensometer Showing Hinge Arrangement.

The arrangement of the hinged joint is shown in Fig. 1. It is made of two ball-and-socket joints of the type used on the valve push-rods of the Chevrolet motor car. The ball part of each joint is threaded into a lug welded to either ring. The sockets are riveted to a short rod. The joint is held together by means of the spring which is fastened at either end to the lugs. Six-inch spacers are used while placing the extensometer on the cylinder and are removed during the test. A lock-nut on each set-screw prevents movement between the ring and the set-screw. All set-screws are case-hardened.

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[1] **Discussion by H. J. Gilkey of paper by C. H. Scholer on "Band Type Circumferential Extensometer for Poisson's Ratio Determinations,"** ***Proceedings,*** **Am. Soc. Testing Mats., Vol. 30, Part I, p. 632 (1930).**

[2] **Stanton Walker, "Modulus of Elasticity of Concrete,"** ***Proceedings,*** **Am. Soc. Testing Mats., Vol. XIX, Part II, p. 510 (1919).**

The particular advantages of this type of instrument are: (1) simplicity of construction and manipulation, (2) the average deformation of the specimen is indicated on a single dial and (3) the dial can be removed before failure of the specimen.

Radial Extensometer.—The lateral or radial extensometer is shown in Fig. 2. This instrument consists of two arms, hinged at the back, with a dial fastened to one arm in front. The joint at the back is designed so that the two arms can be separated and threaded through the longitudinal compressometer after the latter is in place on the specimen. The points of contact with the specimen are two case-hardened, conical-pointed set-screws which are spaced equi-distant from the hinge and the spindle. A small spring between the two arms at the front of the instrument holds the set-screws tightly against the specimen. These set-screws grip the specimen at points diametrically opposite. Thus the deformation indicated on the dial is twice the deformation on the diameter of the cylinder. This arrangement was adopted after some experimentation. As first built, the extensometer had two set-screws on one arm to hold it rigidly on the specimen. It was found, however, to be practically impossible to keep both points in contact with the cylinder.

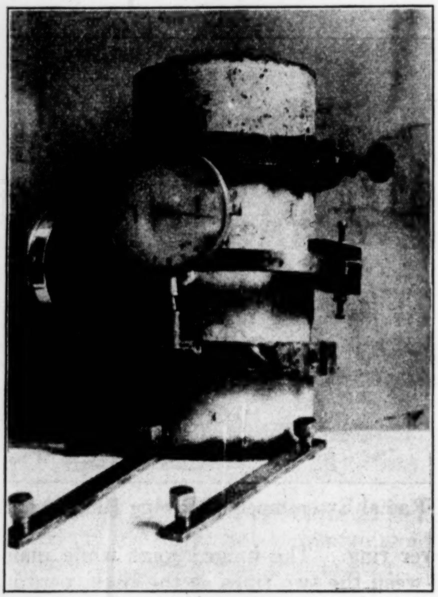

FIG. 3.—Axial and Radial Strainometers on Specimen.

The hinge on the radial extensometer was originally built so that the two arms could be hooked together. This design allowed considerable play with resultant error in the readings but this was corrected by changing the joint to a swivel as shown in Fig. 2.

The left arm of the instrument is held in a fork on the right arm by means of two conical pointed set-screws. These set-screws fit snugly into countersunk holes in the left arm. The only movement which this arrangement will permit is in a plane at right angles to the axis through the two set-screws. The spindle of the dial and the two set-screws which grip the specimen lie in this plane.

To separate the two arms, only the upper set-screw needs to be released as the clearance between the forks of the right arm is sufficient to permit the left arm to be slipped off of the lower set-screw. The lower set-screw is always locked in place. This arrangement allows the lateral extensometer to be threaded through the longitudinal extensometer after the latter is in place on the specimen, but still gives a very rigid joint when assembled. Both instruments in place on a specimen are shown in Fig. 3.

The dials used for both extensometers are Federal Dial Indicators, Model 85, manufactured by the Federal Products Corp., Providence, R. I. These dials are graduated to 0.0001 in. and have a range of 0.2 in. Tenths of a division can be estimated.

The dials were calibrated by means of a set of Johannson-Ford gage blocks before any readings were taken on the specimens. These gage blocks are accurate to within 0.000005 in.

Blocks varying by 0.001 in. were used to determine a range within which the dial readings were accurate. This range was then checked against blocks varying by 0.0001 in. It was found that by using only a certain range on each dial correct readings were obtained and no calibration chart or curve was necessary.

PREPARING THE SPECIMENS FOR TESTING

To provide good bearing surfaces on the ends of the cylinders they were capped with a commercial sulfur capping compound. The sulfur caps were found to be more satisfactory than a mixture of plaster of Paris and cement as they did not deteriorate from the effects of the moisture in the moist room. Since the specimens were not loaded to failure, but were returned to the moist room to be tested at a later date, it was desirable to have a capping compound which would not be affected by moisture.

Specimens were removed from the moist room an hour or two before they were to be tested. This allowed the surface moisture to evaporate but insured a moist condition of the specimens during the tests.

Two spring steel lugs were stuck on the cylinders with plaster of Paris at diametrically opposite points, at about the middle of the specimen. A small punch mark in each of these lugs received one of the conical pointed set-screws of the lateral extensometer. Without these lugs the set-screws would work into the concrete during the test and cause erroneous readings.

As soon as the plaster of Paris under these lugs had hardened, the extensometers were placed on the specimen. The longitudinal compressometer was placed first, care being taken that it would not interfere with the lateral extensometer. The spacers were then removed and the lateral extensometer "threaded" through the longitudinal compressometer.

With the instruments in place the specimen was then placed in the testing machine. The dial on the longitudinal compressometer was made to read zero by adjusting the upper ball joint of the spacer at the back. The dial of the lateral extensometer was adjusted to zero by turning one of the set-screws which grip the specimen. The set-screw was then locked in place with a locknut. The lateral extensometer was supported on the lower head of the testing machine with a short block of wood to prevent it from turning about the set-screws.

All tests were made in a 200,000-lb. Olsen universal testing machine. A head with a 3-in. spherical bearing had been made for this machine and was used in a large number of the tests. A heavy steel plate 1½ in. in thickness and 6 in. in diameter was used to distribute the load over the 6 by 12-in. specimens. Some of the later tests were made with a specially made head having a 6-in. spherical bearing. No variations in the results could be detected when these two heads were used on alternate tests on the same specimen.

With the exception of the tests at an age of one year, practically all tests were made by applying the load by increments. Each increment of load was sustained until no increase in the deformation could be noted on the dial before the readings were taken. For loads up to 200 lb. per sq. in. this required about one minute. Three minutes were allowed at higher loads. Readings were taken at increments of 2000 lb. total load up to 10,000 lb., and at 5000 lb. increments above that load.

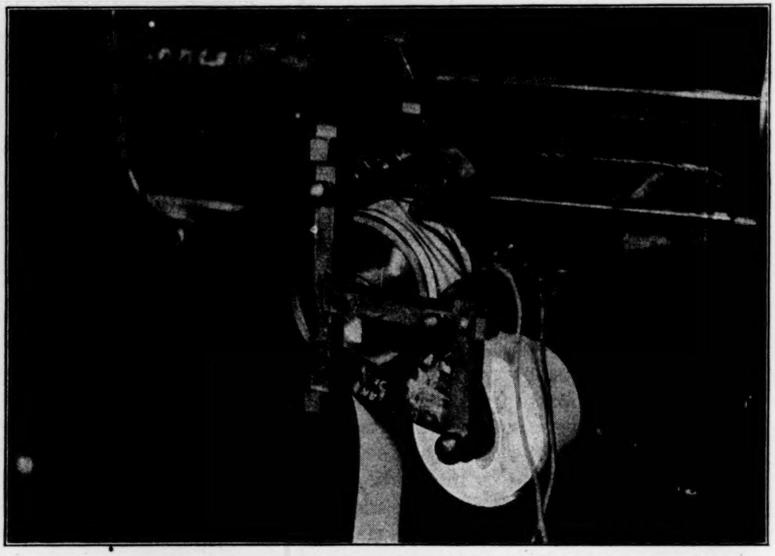

FIG. 4.—Autographic Recording Device; Used for Continuous Loading.

In most cases the maximum load applied was about 1200 lb. per sq. in. The load was then released and the specimen allowed to "rest" for 3 minutes and a second set of data taken. About 80 minutes were required to prepare each specimen, attach the instruments, and run the two tests. After being tested the specimens were returned to the moist room and kept until a later date when the tests were repeated. Tests were made at ages of 14, 28, 56 and 112 days on the sand-gravel specimens, and at 14, 28 and 56 days on the mixed-aggregate specimens.

At the present time, these same specimens are being tested at an age of one year. Since the 112-day tests, the specimens have been stored in laboratory air which is fairly constant at 70° F.

Continuous loads are being used in these tests and data taken by means of the autographic device shown in Fig. 4. The bronze drum is geared to the mechanism which drives the poise of the testing machine. The paper travels over this drum at a rate corresponding to the travel of the poise. Small pinholes are burned through the paper by means of an electric spark.

In running a continuous test, the poise is first set at zero with zero load on the specimen. The corresponding point on the paper is marked by pressing a telegraph key and burning a hole. As the load on the specimen increases, the machine operator must keep the beam in perfect balance. A recorder watches the dial on the extensometer and burns a hole in the paper at equal increments of deformation. This can be done without stopping the machine. The distance between pin holes represents to a given scale the increase in total load between the increments of deformation.

If both axial and radial deformations are desired, two recorders and two spark gaps are used. It has been found convenient to record the load at increments of five divisions of the dial for axial deformation and for each division of the dial for radial deformation. The dials are graduated to 0.0001 in. About 20 minutes are required to attach the instruments to a specimen and make two applications of the load.

After the test is completed the ribbon of paper is torn off and the load at each mark scaled off and plotted. A celluloid scale graduated to read directly in pounds per square inch for a 6-in. cylinder has been found convenient for this purpose. Plotting is done over a glass plate which is lighted from below. A master sheet ruled to correspond to the increments of deformation used and placed beneath the coordinate paper on which the curve is to be plotted is a convenience in plotting.

DISCUSSION

Speed of Loading.—If a concrete specimen is stressed with extensometers in place and a constant load maintained, the readings on the dials will increase for several minutes. This increase is due to the plastic flow of the cement paste and probably continues to some extent as long as the load is maintained. However, after two or three minutes the increase is so small that it can barely be detected on the dials.

Since most of the loads to which concrete structures are subjected are loads of long duration, the question arose as to whether or not "flash" loads applied to the specimen would give the true stress-strain relation. It was finally decided to apply the loads by increments and to maintain each increment of load until no further increase in the dial readings could be noted. All tests with the exception of those at one year of age are run in this manner unless otherwise noted. The tests at one year are all "flash" loadings.

Tests run on a number of specimens at ages as great as 4 months indicate that the speed of loading has very little effect upon either the modulus of elasticity or Poisson's ratio. Several applications of loads up to 1200 lb. per sq. in. were made on these specimens. The speed of loading was varied on the different runs from 2 minutes to 24 minutes.

Data for typical specimens tested in this manner are given in the following table:

EFFECT OF REPEATED LOADS AND SPEED OF LOADING.

Time from 0 to 1000 lb. per sq. in. unit stress.

Specimen	Age, days	24 Minutes			2 Minutes		
		Run Number	Modulus of Elasticity, E, lb. per sq. in.	Poisson's Ratio	Run Number	Modulus of Elasticity, E, lb. per sq. in.	Poisson's Ratio
No. 4472........	140......	4.........	4 115 000	0.198	7.........	4 274 000	0.182
		5.........	4 167 000	0.204	8.........	4 292 000	0.189
		6.........	4 132 000	0.186	9.........	4 220 000	0.190
		10.........	4 202 000	0.207	....	....	....
		Average..	4 154 000	0.199	Average..	4 262 000	0.187
No. 5492........	125......	2.........	2 725 000	0.224	5.........	2 717 000	0.206
		3.........	2 667 000	0.208	6.........	2 695 000	0.210
		4.........	2 660 000	0.210	7.........	2 695 000	0.210
		9.........	2 645 000	0.209	8.........	2 733 000	0.203
		Average..	2 675 000	0.213	Average..	2 710 000	0.207

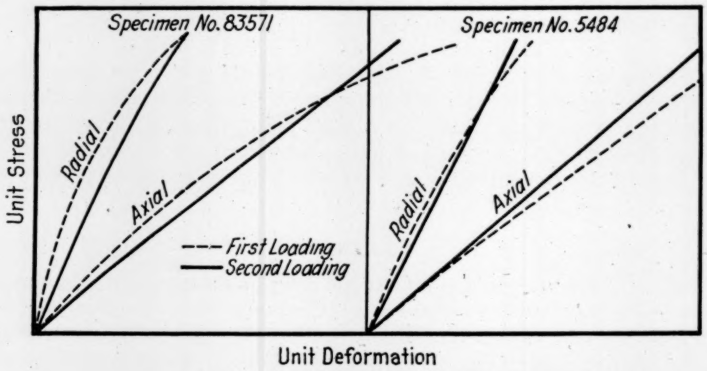

FIG. 5.—Stress-Strain Diagrams for First and Second Loadings.

Fineness modulus..................	3.8	Fineness modulus....................	3.5
Mix..............................	1:3½	Mix................................	1:4
Water-cement ratio................	0.7	Water-cement ratio..................	0.8
Age..............................	14 days	Age................................	56 days

NOTE.—Scale of radial deformation is twice that of axial deformation.

From a study of these data it appears that the speed of loading has no marked effect on the values of either the modulus of elasticity or Poisson's ratio within the limits of unit stress used in these tests. It is true that the values of the modulus of elasticity, E, are slightly higher for the "flash" loads but the difference is so small as to be negligible. The values of Poisson's ratio are lower for the "flash" loads but again the differences are slight.

It will be apparent that a considerable saving of time can be made by using flash loadings if the difference in results is not greater than that indicated. In all tests at one year, flash loads have been used.

Repeated Application of Loads Within the Elastic Limit.—In general, the specimens were stressed to about 1200 lb. per sq. in. on two applications of the load, and only the second set of data recorded. However, in numerous cases the data for both the first and second applications were recorded. Typical curves plotted for both sets of data are shown in Fig. 5. A comparison of the curves obtained shows no definite variation between the slopes of the curves for the first and second applications. About as many specimens showed a decrease as did an increase. In a good many cases exactly the same values were obtained for both applications.

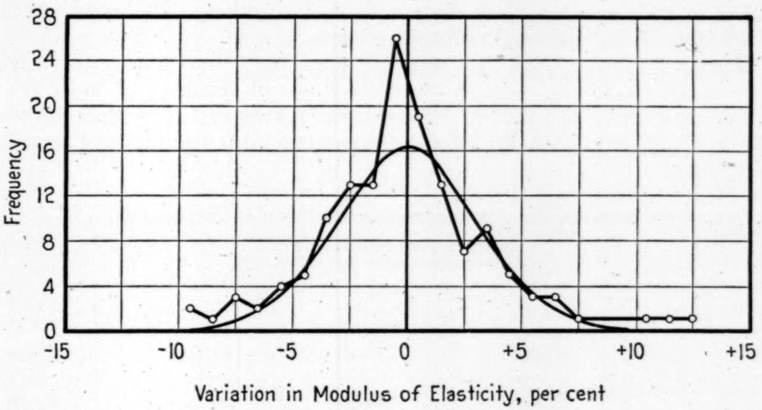

FIG. 6.—Variation of Modulus of Elasticity Between First and Second Loading.

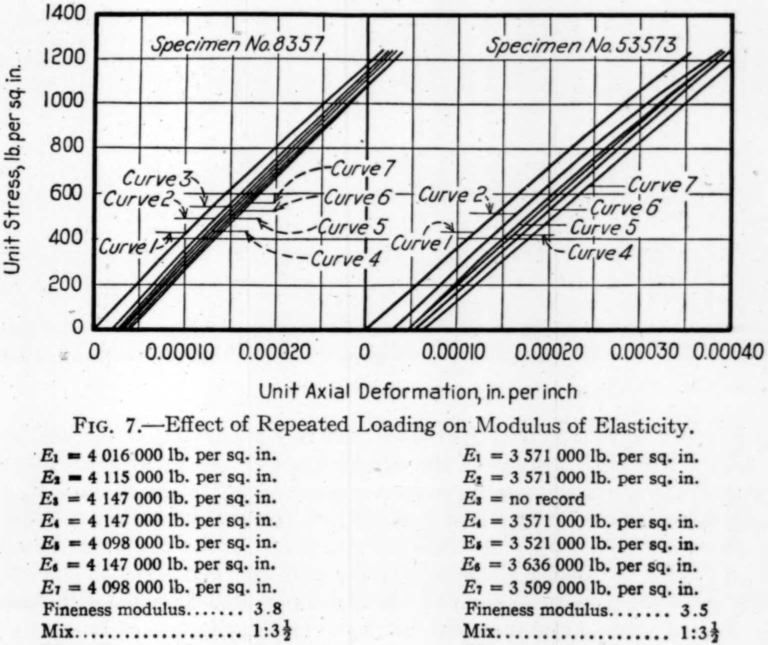

FIG. 7.—Effect of Repeated Loading on Modulus of Elasticity.

E_1 = 4 016 000 lb. per sq. in.	E_1 = 3 571 000 lb. per sq. in.
E_2 = 4 115 000 lb. per sq. in.	E_2 = 3 571 000 lb. per sq. in.
E_3 = 4 147 000 lb. per sq. in.	E_3 = no record
E_4 = 4 147 000 lb. per sq. in.	E_4 = 3 571 000 lb. per sq. in.
E_5 = 4 098 000 lb. per sq. in.	E_5 = 3 521 000 lb. per sq. in.
E_6 = 4 147 000 lb. per sq. in.	E_6 = 3 636 000 lb. per sq. in.
E_7 = 4 098 000 lb. per sq. in.	E_7 = 3 509 000 lb. per sq. in.
Fineness modulus....... 3.8	Fineness modulus....... 3.5
Mix.................. 1:3½	Mix.................. 1:3½
Water-cement ratio..... 0.7	Water-cement ratio 0.7
Age.................. 84 days	Age.................. 31 days

When the values of modulus of elasticity, E, obtained for the second application were expressed as a percentage of the value obtained on the first application, it was found that the average of all of these percentages was 100. These values were then divided into groups according to the percentage of variation from the mean. The broken-line curve in Fig. 6 was obtained by plotting the number in each group against the percentage variation. The curve obtained follows very closely a normal probability curve.

Figure 7 shows curves that were obtained from numerous repeated loads on the same specimens. Values of the modulus of elasticity obtained on the several applications are shown. From these curves and also from the above table, it is apparent that the effect of repeating loads within the elastic limit is very slight.

TABLE III.—DEFORMATIONS OF TYPICAL SPECIMENS.

Deformations in 0.000001 in. per inch.
Data for second application of load only.

Total Load, lb.	Stress, lb. per sq. in.	Specimen							
		No. 5471		No. 8471		No. 1465		No. 83574	
		28 Days		28 Days		112 Days		112 Days	
		Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0	0
2 000	70	16	3	17	3	17	2	12	3
4 000	141	34	7	35	7	35	5	29	8
6 000	212	52	10	53	11	52	7	44	10
10 000	354	91	18	91	17	85	13	74	18
15 000	530	144	28	138	26	129	22	117	27
20 000	707	193	40	187	36	182	32	161	37
25 000	884	246	50	237	47	221	40	204	46
30 000	1061	300	61	286	57	269	49	247	58
35 000	1237	345	72	333	66	317	58	294	69
40 000	1414	401	86	386	80	369	72	338	79
45 000	1591	461	103	441	92	422	87	396	96
50 000	1768	534	121	505	112	484	109	450	115
55 000	1944	608	141	568	132	553	134	506	136
60 000	2121	...	...	...	...	635	171	571	160
65 000	2298	...	...	...	...	731	223	644	188
70 000	2475	...	...	...	...	841	307	725	225
75 000	2652	...	...	...	...	...	...	823	277
Poisson's Ratio		0.201		0.195		0.178		0.221	
Modulus of Elasticity, lb. per sq. in.		3 584 000		3 759 000		3 952 000		4 167 000	

It would seem then that the values from any application of the load might be used. However, a study of the actual shape of the stress-strain diagrams in Fig. 5 will show that the curve for the second application of the load more nearly approaches a straight line than that of the first application. After the second application, very little change in the shape of the curve can be noted. The curve for the second application of the load has been taken as more representative of the actual condition of concrete and is used throughout this report.

Typical stress-strain diagrams for the second application of loads on sand-gravel concrete are given in Figs. 8 and 9. Table III gives detailed information on the deformation from which these curves were plotted.

Failure of the concrete to regain its original dimensions upon removal of the load is indicated by the repeated curves of Fig. 7. Apparently the plastic flow is greater for the first loading than for the subsequent applications, but it continues to a certain extent for each application of the load.

Stresses Beyond the "Elastic Limit."—Both the axial and radial stress-strain diagrams are practically straight lines for loads within the limits usually allowed in design. This is especially true at the later ages. Secant values of the modulus of elasticity and Poisson's ratio at 1000 lb. per sq. in. have been used throughout this report, and in most cases do not vary materially from the initial tangent values.

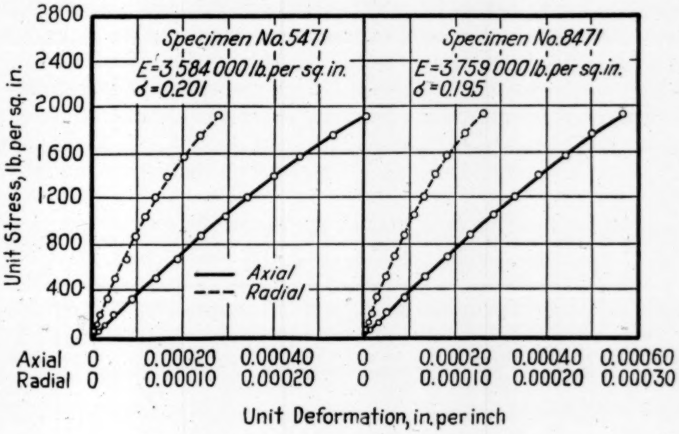

FIG. 8.—Typical Stress-Strain Diagrams.

Fineness modulus	3.5	Fineness modulus	3.8
Mix	1:4	Mix	1:4
Water-cement ratio	0.7	Water-cement ratio	0.7
Age	28 days	Age	28 days
Compressive strength	3052 lb. per sq. in.	Compressive strength	3309 lb. per sq. in.

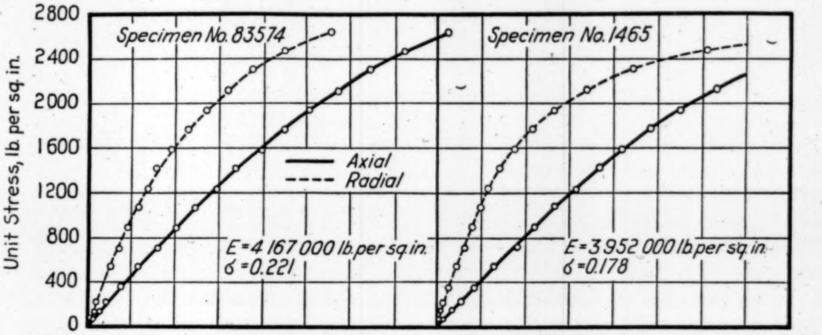

FIG. 9.—Typical Stress-Strain Diagrams.

Fineness modulus	3.8	Fineness modulus	4.1
Mix	1:3½	Mix	1:4
Water-cement ratio	0.7	Water-cement ratio	0.6
Age	112 days	Age	112 days
Compressive strength	3263 lb. per sq. in.	Compressive strength	2885 lb. per sq. in.

At higher stresses both curves become concave downward, the radial deformation increasing more rapidly than the axial deformation. A number of specimens were tested continuously to failure after the 112-day tests had been made. Shortly before failure the extensometers were removed from the specimen. The rings of the axial extensometer could not be entirely removed without raising the head of the testing machine. To avoid this they were released and held free of the specimen. This prevented damage to the instruments on failure of the specimen. For loads slightly below the ultimate strength, the deformations increased so rapidly that it was impossible to take the readings. The increase of the radial deformation was much more pronounced than the axial deformation.

From Fig. 9 it can be seen that at the higher stresses the curve for radial deformation is quite rapidly approaching the curve of axial deformation. Should these two curves cross, the value of the non-elastic equivalent of Poisson's ratio at this point would be one-half since the scale of radial deformation is twice that of axial deformation. If this value is greater than one-half the volume of the material will increase; such a condition is improbable under a compressive load. It is the opinion of the author that if readings could be taken up to the instant of failure a value for this non-elastic equivalent of Poisson's ratio of one-half would be found at this point. If the curves of Fig. 9 are extended until they intersect as suggested above, the unit stress at this point will be found to be very close to that actually recorded for each specimen. The ultimate strengths of these specimens are given on the diagrams.

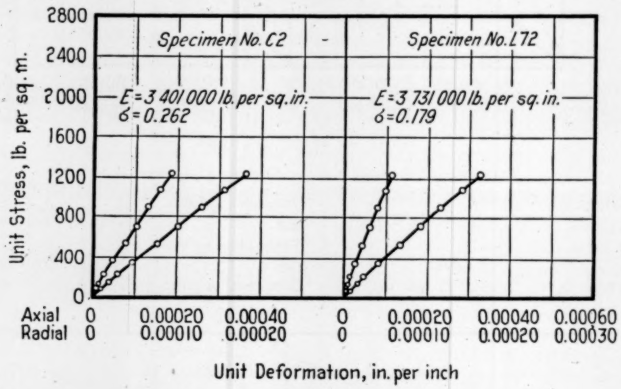

FIG. 10.—Typical Stress-Strain Diagrams.

Neat Cement	
Water-cement ratio	0.4
Age	28 days
Compressive strength	7264 lb. per sq. in.

Local Limestone	
Mix	1:1¾:3½
Water-cement ratio	0.7
Age	28 days
Compressive strength	4058 lb. per sq. in.

Previous Condition of Loading.—Five specimens were made in each series of the sand-gravel group and numbered consecutively from one to five. At 14 days of age, specimen No. 1 was tested. At 28 days, Nos. 1, 2 and 3 were tested. At 56 and 112 days, all five specimens were tested. In the mixed aggregate group only four specimens were made in each series. Of these, two were tested at 14 days and all of the specimens in the series were tested at

28 and 56 days. The values given in the tables represent average values for the number of specimens tested at the given age.

There is no indication from these tests that the values of modulus of elasticity, E, or Poisson's ratio are affected by previous applications of loads within

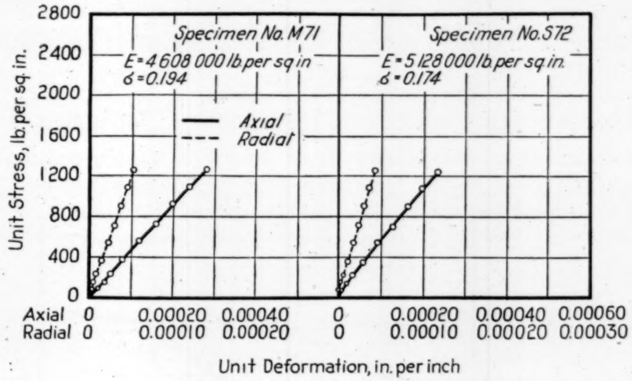

FIG. 11.—Typical Stress-Strain Diagrams.

Moline Limestone	
Mix	1:1¾:3½
Water-cement ratio	0.7
Age	28 days
Compressive strength	4402 lb. per sq. in.

Lincoln Sandstone	
Mix	1:1¾:3½
Water-cement ratio	0.7
Age	28 days
Compressive strength	3938 lb. per sq. in.

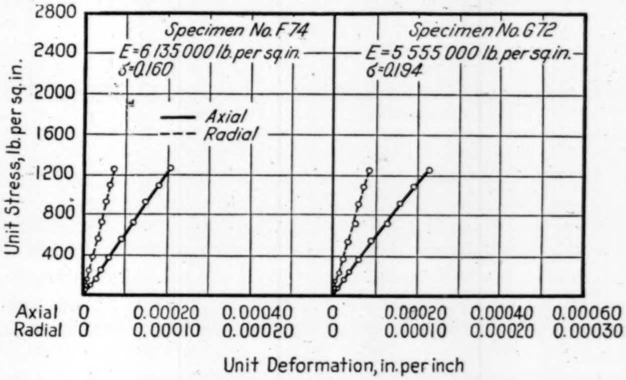

FIG. 12.—Typical Stress-Strain Diagrams.

Joplin Flint	
Mix	1:1¾:3½
Water-cement ratio	0.7
Age	28 days
Compressive strength	3057 lb. per sq. in.

Silverdale Gravel	
Mix	1:1¾:3½
Water-cement ratio	0.7
Age	28 days
Compressive strength	3085 lb. per sq. in.

the "elastic limit." In a number of cases, specimens were loaded to a point beyond the "elastic limit" of the material. On subsequent tests it was very apparent that the material had been injured and the properties of the material had been permanently changed. Because of the limited number of observations no definite conclusions have been attempted in regard to the effect of previous loading.

Effect of Character of Aggregate.—The following coarse aggregates were used in the mixed aggregate group of specimens:

Local limestone; a soft limestone;
Moline limestone; a fairly dense, gray limestone;
Lincoln sandstone; a dense sandstone composed of siliceous sand cemented with calcium carbonate;
Joplin flint; a very hard impervious chert;
Silverdale gravel; a very hard chert similar to Joplin flint.

Fine aggregate used was Kansas River sand with a fairly constant fineness modulus of about 2.75.

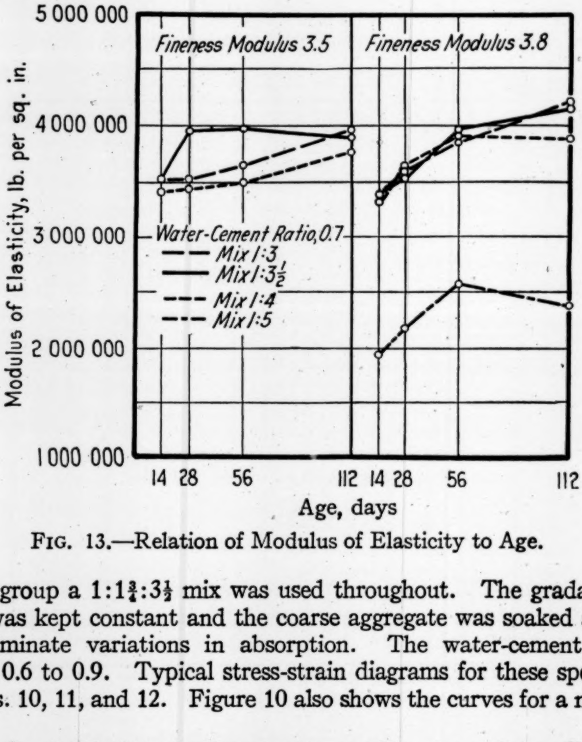

FIG. 13.—Relation of Modulus of Elasticity to Age.

In this group a 1:1¾:3½ mix was used throughout. The gradation of the aggregates was kept constant and the coarse aggregate was soaked and surface dried to eliminate variations in absorption. The water-cement ratio was varied from 0.6 to 0.9. Typical stress-strain diagrams for these specimens are given in Figs. 10, 11, and 12. Figure 10 also shows the curves for a neat cement specimen.

Curves shown for the mixed aggregate specimens are chosen from the 0.7 water-cement ratio series for each type of aggregate at an age of 28 days.

There is a very pronounced difference in the slopes of the curves for the different types of aggregate. The curves for the hard, flinty aggregates are much steeper than for the softer aggregates. This is further emphasized in the diagrams showing the relation of modulus of elasticity to age in Fig. 16. It is interesting to note the way in which the two flinty aggregates are grouped together with extremely high values of *E;* the sandstone and the dense limestone are grouped together with somewhat lower values of *E,* and the soft limestone even lower. This grouping is quite distinct for each water-cement ratio and at all ages.

Since the deformation represented by the curves is partly an elastic deformation of the aggregate, it is reasonable to expect that the higher values of E would be obtained for the concrete made of the harder aggregates.

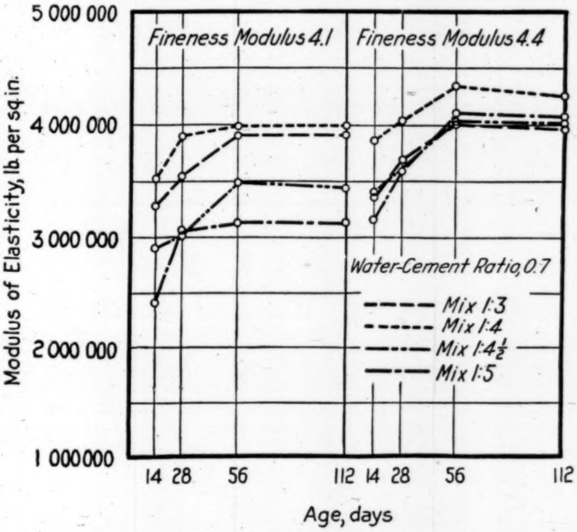

FIG. 14.—Relation of Modulus of Elasticity to Age.

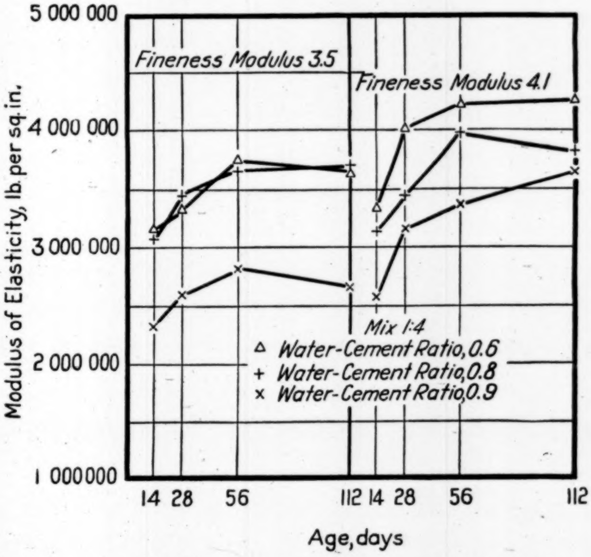

FIG. 15.—Relation of Modulus of Elasticity to Age.

Age at Test.—The effect of age upon the modulus of elasticity is shown by Figs. 13, 14, 15 and 16.

These curves show a rapid increase in the value of E with age up to 56 days. From 56 to 112 days, about half of the curves show a slight increase in the value of *E* while the rest show a very slight decrease. It is possible that the effect of loading at earlier ages has been to decrease the modulus of elasticity at the later ages. Reports of other investigators, however, indicate that the modulus of elasticity is increased by previous loading.

Tests on these specimens at an age of one year are in progress at the present time. Available data at this age indicate a decided decrease in the value of *E*; some values being even lower than those obtained on the 14-day tests. Because of the fact that these cylinders were not returned to the moist room after the 112-day tests, but were stored in laboratory air at room temperature, there is some question as to the correct interpretation to place on the one-year tests.

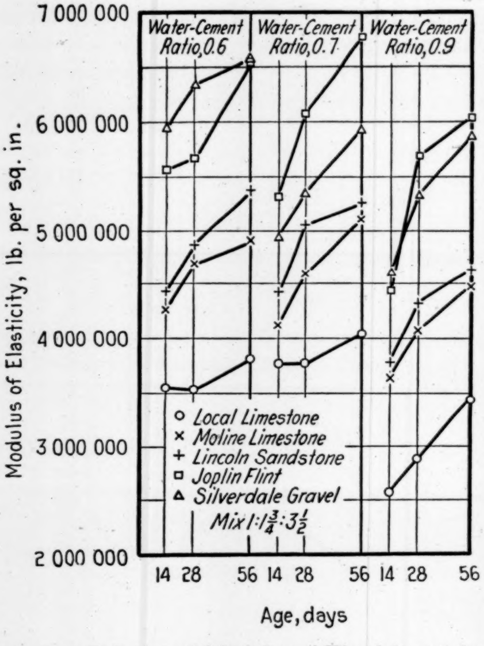

FIG. 16.—Relation of Modulus of Elasticity to Age.

Although some other investigators have reported a decrease in the value of *E* at later ages, it hardly seems possible that such large decreases as our results indicate could be due to this factor alone. It is quite probable that it is due more to the change in curing conditions or to the previous loading. Further investigation of the effect of age is being planned.

In general, the value of *E* for each series in the sand-gravel group at a given age is based upon one specimen at 14 days, an average of three specimens at 28 days, and five specimens at 56 and 112 days. In the mixed aggregate group, the values are based upon an average of two specimens at 14 days and four specimens at 28 and 56 days. It is interesting to note that the deviation of the value of *E* for any specimen from the average value for the series exceeded 10 per cent in only 14 cases.

No definite conclusions can be drawn in regard to the effect of age upon Poisson's ratio. However, the following comparison of the average values of

Poisson's ratio for all specimens tested at the different ages indicates a gradual increase with age.

AGE, DAYS	POISSON'S RATIO
14	0.182
28	0.184
56	0.204
112	0.206

Figure 16 emphasizes the effect of the character of the coarse aggregate upon the value of the modulus of elasticity. The grouping of the types of aggregate is shown particularly well.

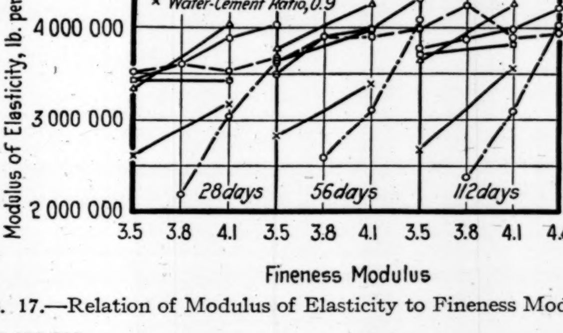

FIG. 17.—Relation of Modulus of Elasticity to Fineness Modulus.

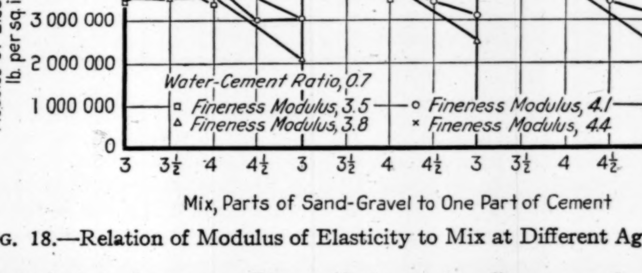

FIG. 18.—Relation of Modulus of Elasticity to Mix at Different Ages.

Gradation of the Aggregate.—Figure 17 shows the effect upon the modulus of elasticity of variations in the gradation of the aggregate for the sand-gravel specimens. The fineness modulus was varied from 3.5 to 4.4. Curves are given for various mixes and water-cement ratios at three different ages. It is quite apparent that for this type of concrete there is a very decided tendency for the value of E to increase with the fineness modulus.

There is no definite relation between the fineness modulus and Poisson's ratio within the limits of these tests.

Richness of Mix.—The effect on the modulus of elasticity of variation in the richness of the mix for sand-gravel concrete is shown in Fig. 18. Curves are given for each fineness modulus used and a water-cement ratio of 0.7 at ages of 28, 56 and 112 days. It is interesting to note that E is a maximum for a mix of 1:3½ or 1:4, and drops off somewhat for both richer and leaner mixes, though to a greater extent for the leaner mixes. However, the richer mixes show a greater increase in the modulus of elasticity with an increase in age. At 112 days two of the groups of specimens show a maximum value of E for the 1:3 mixes. Similar results have been reported by Davis and Troxell.[1]

Variation in the richness of mix has no pronounced effect upon the value of Poisson's ratio.

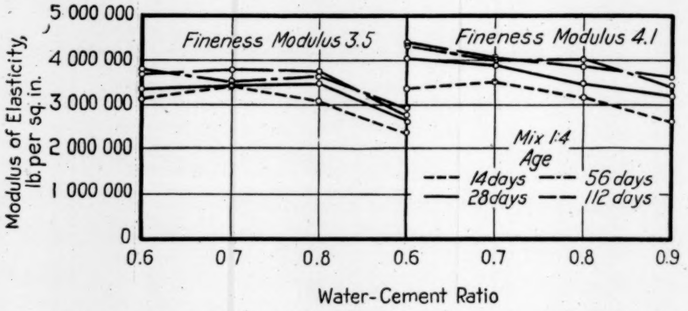

FIG. 19.—Relation of Modulus of Elasticity to Water-Cement Ratio.

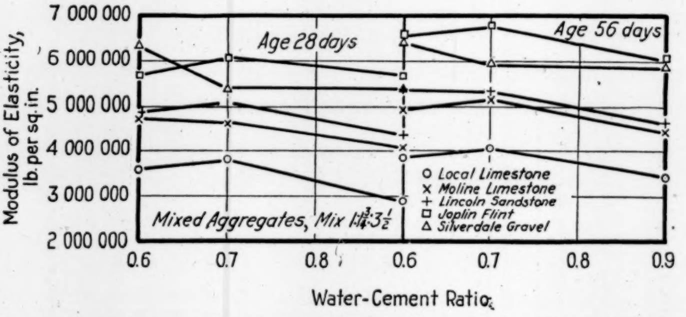

FIG. 20.—Relation of Modulus of Elasticity to Water-Cement Ratio.

Water-Cement Ratio.—Figures 19 and 20 show the effect on the modulus of elasticity of variations in the water-cement ratio. The curves for a 1:4 mix of sand-gravel aggregate for two gradations and four ages are given in Fig. 19. Figure 20 shows the curves for the different types of coarse aggregate at two different ages. All of the curves show lower values of E for the higher water-cement ratios. There is some tendency to reach a maximum for a water-cement ratio of 0.7 with a lower value at 0.6. This may be due to the fact that in general, the mixes using a water-cement ratio of 0.7 are more workable than the drier mixes.

Comparative values for the various types of coarse aggregate used are well shown in Fig. 20.

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[1] R. E. Davis and G. E. Troxell, "Modulus of Elasticity and Poisson's Ratio for Concrete, and the Influence of Age and Other Factors Upon These Values," *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part II, p. 678 (1929).

Oven Drying.—Figure 21 shows the effect of oven drying upon the modulus of elasticity. The first curve shows the value of E at 112 days and in a moist condition. The specimen was then placed in an oven and maintained at a temperature of about 100° C. for a couple of days, after which it was allowed to stand in the laboratory until tested at 117 days. The third curve was obtained after the specimen has been soaked in water over night and allowed to stand in the moist room for several days. The specimen was again returned to the moist room and a fourth test run in a moist condition at 139 days. The fifth curve was obtained with the specimen again in a dry condition. The last curve was obtained after the specimen had been soaked and returned to the moist room for several days.

This test probably does not give a true idea of the effect of moisture on the value of E. The difference in the values obtained shows that the specimen had been permanently injured. This is probably due to the effect of the high degree of heat more than the driving off of moisture. These two variables have not been separated in this test and therefore no definite conclusions can be drawn as to the effect of either variable by itself.

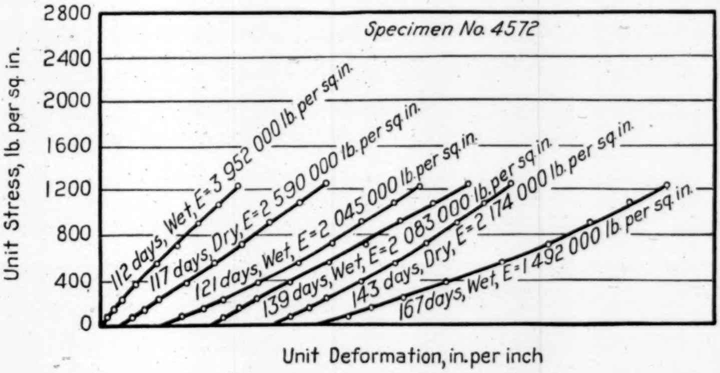

FIG. 21.—Effect of Oven-Drying on Modulus of Elasticity; Oven Temperature 100° C.

28-day Strength.—Figure 22 shows the relation of E to the 28-day strength as obtained on 3 by 6-in. specimens. Each point plotted indicates the average of the number of specimens tested in a series at 28 days. The full line curve is an average curve for the sand-gravel or "total aggregate" specimens. The dotted line represents the 1924 Joint Committee[1] recommendations for values of E based upon the 28-day strength.

It will be noted that the values of E for the "total aggregate" and the local limestone are not far from these recommendations. For the Moline limestone and Lincoln sandstone the values are about 50 per cent higher than the recommendations and for the two flinty aggregates they are about 100 per cent higher. It is apparent that in determining the value of E to be used in design, it is not always sufficient to depend solely upon the 28-day strength of the concrete to be used.

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[1] **Report of Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. See *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 303 (1924).**

Of the variables studied in this investigation, the character of the aggregate has the greatest effect upon the values of the modulus of elasticity. Within the limits of this report, the variation in E may be as great as 100 per cent between the soft limestone and the flinty aggregates. This difference is quite noticeable in all of the curves plotted for mixed aggregate concrete.

There is no definite relation between the modulus of elasticity and the ultimate 28-day strength for concrete made of various types of aggregate. There is, however, some indication that for a given type of aggregate the modulus of elasticity increases with the ultimate strength.

Since under certain conditions such as temperature changes an increase of 100 per cent in the value of E may mean an increase of 100 per cent in the unit stresses actually existing, the design of any important structure should be preceeded by a careful investigation of the elastic properties of the material to be used.

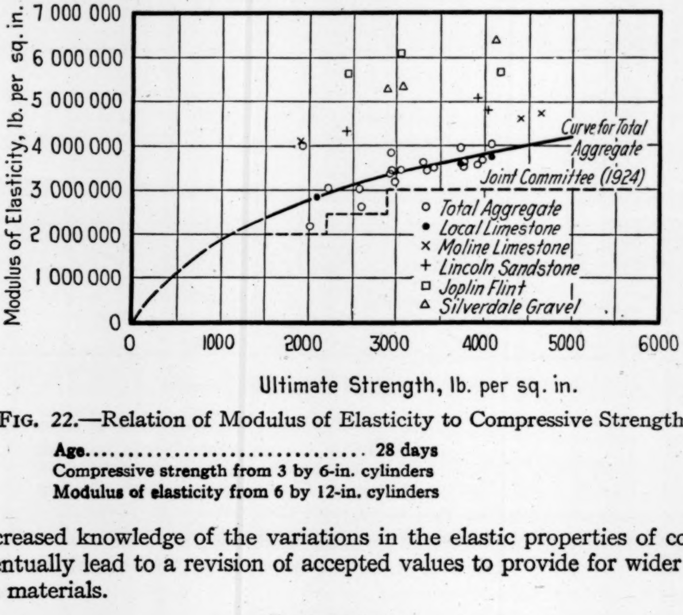

FIG. 22.—Relation of Modulus of Elasticity to Compressive Strength.

Age.............................. 28 days
Compressive strength from 3 by 6-in. cylinders
Modulus of elasticity from 6 by 12-in. cylinders

Increased knowledge of the variations in the elastic properties of concrete will eventually lead to a revision of accepted values to provide for wider variations in materials.

CONCLUSIONS

1. Variations in the speed of application of loads below the "elastic limit" have no great effect upon either the modulus of elasticity or Poisson's ratio.

2. The effect on the modulus of elasticity and Poisson's ratio of repeated loads within the "elastic limit" is very slight for secant values at 1000 lb. per sq. in.

3. The stress-strain diagrams for the second application of a load below the "elastic limit" more nearly approach a straight line than those for the first application. For repeated applications after the second loading, very little change in the shape of the curves can be noted.

4. At stress beyond the "elastic limit," the radial deformation increases more rapidly than the axial deformation. A maximum value of Poisson's ratio of one-half is indicated.

5. There is a very pronounced difference in the shape of the curves for different types of aggregate. The curves for the hard flinty aggregates are much steeper than for the softer aggregates. The very marked effect of variations in aggregate upon the value of the modulus of elasticity is particularly significant, the extent of this variation being such that it should by all means enter into the design of reinforced concrete structures.

6. The value of E increases quite rapidly up to 56 days of age. After this age the increase is less rapid and there is some indication that there is a decrease at later ages. Poisson's ratio apparently increases very slightly with age.

7. For sand-gravel concrete there is a decided tendency of the value of E to increase with an increase in the fineness modulus. There is no definite relation between the fineness modulus and Poisson's ratio within the limits of these tests.

8. A maximum value of E for sand-gravel concrete was obtained for mixes of 1:3½ to 1:4 with lower values for the richer and leaner mixes. However, the richer mixes show a greater increase with age.

Variation in the richness of mix has no pronounced effect on the value of Poisson's ratio.

9. Maximum values of the modulus of elasticity occur for a water-cement ratio of 0.7.

10. The very pronounced decrease in the value of the modulus of elasticity due to drying at 100° C. shows that the properties of the concrete were materially changed. A more detailed study should be made to determine the effects of moisture content and of drying at various temperatures. Other investigators have observed that the boiling of concrete and drying at high temperatures permanently alters the character of the concrete.

11. There is no definite relation between the modulus of elasticity and the 28-day strength for concrete made of various types of aggregate. For a given aggregate an increase in the ultimate strength is accompanied by an increase in the modulus of elasticity.

DISCUSSION

Mr. D. A. Abrams.[1]—Referring to the paper by Mr. Noble, it would be a distinct improvement if the extensometer were designed so that the movable ring would not be compelled to rotate against the friction that holds it in place. That can be easily done by providing an auxiliary floating ring which rests on the lower fixed ring by a two point contact. Instruments are available which are based on this principle.

Mr. W. A. Slater.[2]—During the past year results have been published in England by W. H. Glanville[3] which give interesting comments on the modulus of elasticity. Mr. Glanville says:

> It is demonstrated that during loading the relation between stress and strain, for concretes of the types tested, departs from direct proportionality by an amount depending on the creep taking place, and therefore on the rate of loading. The true modulus of elasticity is that which would theoretically be obtained with instantaneous loading, and this is equal to the tangent value at the origin for the mixes examined.

R. E. Davis[4] has also pointed out that the flow in concrete is proportional to the stress applied. If these conclusions are correct, it follows that the straight-line formula for computation of the stresses in a concrete beam is not merely the most convenient analysis to use, but it is exact.

To test the correctness of these conclusions, tests were made on twenty-seven 6 by 12-in. concrete cylinders at Lehigh University in which the length of time required for applying the load was decreased successively from twenty minutes to one second.

The concrete was of 1:2.17:3.26 mix by weight of the dry materials and the net water content was 39 gal. per cu. yd. of concrete, or 6.5 gal. per sack of cement. An amount of water corresponding to 0.7 per cent of the weight of the dry aggregates was added to the mix to compensate for absorption. The concrete was mixed for one minute dry and three minutes wet, in a mixer of 2.5 cu. ft. capacity. Each batch had sufficient material for nine cylinders. Three batches were required for the series and all three were made on the same day. The consistency of the concrete corresponded to an average slump of 3 in. The cylinders were made and capped in accordance with ordinary laboratory practice and moist-cured until reaching an age of 28 days. Steel plugs, $\frac{5}{8}$ in. in diameter and $\frac{1}{4}$ in. in thickness were set in the concrete so as to form two 8-in. longitudinal gage lines, one on each end of a diameter of the cylinder. Five cylinders from each batch (making a total of 15 cylinders) were so prepared. These plugs were set in the concrete with neat cement paste.

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[1] Consulting Engineer, New York City.

[2] Research Professor of Engineering Materials, and Director, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

[3] W. H. Glanville, "The Creep or Flow of Concrete Under Load," Department of Scientific and Industrial Research, Building Research, *Technical Paper No. 12*.

[4] Raymond E. Davis and Harmer E. Davis, "Flow of Concrete Under the Action of Sustained Loads," *Journal*, Am. Concrete Inst., March, 1931, p. 865.

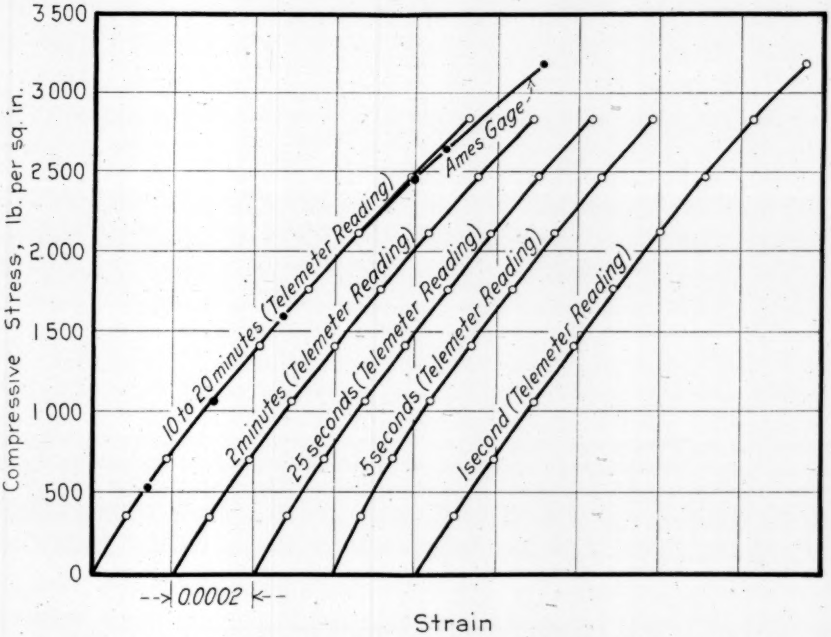

FIG. 1.—Modulus of Elasticity of Concrete Determined at Different Speeds.

When 28 days old, the cylinders having steel plugs were taken to the testing laboratory of the General Steel Castings Co. at Eddystone, Pa., and tested for modulus of elasticity in an Emery-Tatnall hydraulic machine of 100,000 lb. capacity. The machine was equipped with a telemeter which registers the hydraulic pressure. The deformation of the cylinders was measured by means of two 8-in. telemeters (one on each side of the cylinders), clamped against the steel plugs. All the telemeters and an electric timer were connected to an oscillograph equipped with a photographic recording camera. With proper adjustment this equipment gave a photographic record of the load and deformation. Five rates of testing were used, and three cylinders were tested at each rate. The rates at which the cylinders were loaded corresponded to the time required to bring the load from zero to 90,000 lb. in 10 minutes, 2 minutes, 25 seconds, 5 seconds, and 1 second, respectively. Two cylinders for the ten minutes testing time were tested on the day scheduled, and the third on the following day at which the time required for testing the third cylinder was about 20 minutes. This difference in time was probably due to the difference in oil temperature on the two days.

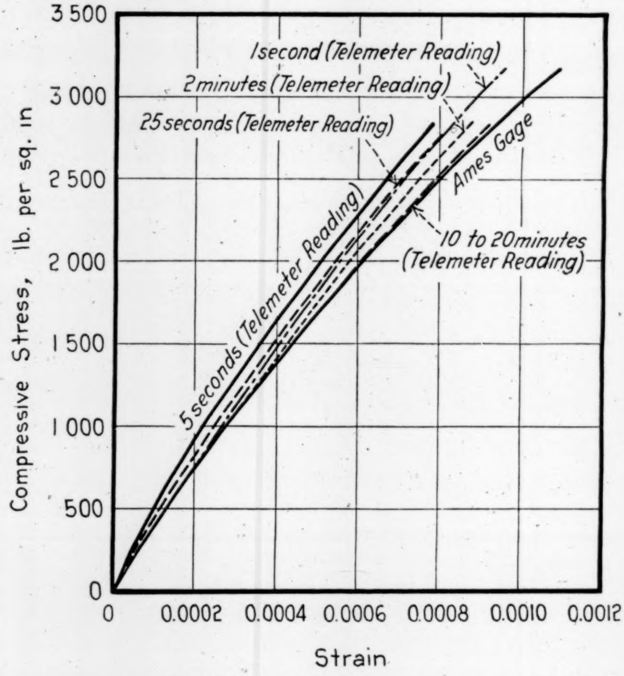

FIG. 2.—Modulus of Elasticity of Concrete Determined at Different Speeds of Head of Testing Machine.

Two cylinders from each batch, or a total of six cylinders, were tested directly to failure at the age of 28 days. The remaining two cylinders from each batch were tested for modulus of elasticity with the same type of apparatus as shown by Mr. Noble, that is, Ames dials clamped directly to the concrete. The dials were left on the specimen until a load of 105,000 lb. had been reached. They were then removed and the load increased until the specimen failed.

The average strength of the cylinders tested to failure was 4220 lb. per sq. in. and the maximum and average variations from average strength were 6.9 per cent and 2.7 per cent.

The accompanying Fig. 1 shows the stress-strain curves for the specimens tested at different speeds. In Fig. 2 the same curves are drawn from the same origin and in addition, the curve obtained by the use of Ames dials is shown also.

Figure 1 shows that for the slowest application of load when tested with the recording devices, the strains agreed well with those found by the usual laboratory method in which the strain was measured by means of an Ames gage. This gives some degree of confidence in the methods used for measuring the load and the strain. The successive stress-strain curves show some straightening as the time of loading became smaller, and the curve for the loading time of one second is the straightest of all. However, the amount of straightening was not progressive throughout the series. In spite of this exception the results thus far are in reasonable conformity with the conclusions of Glanville and Davis. Glanville's conclusion, however, required not only that as the time of loading decreases the stress-strain curve should become straighter, but also that all the stress-strain curves should have a common tangent at zero load. That this condition is not fulfilled is shown in Fig. 2, in which the slope of the initial tangent would be less for the one-second loading than for the 5- and the 25-second loadings. Thus the tests give only partial support to the conclusions arrived at by Glanville.

MR. T. C. POWERS.[1]—In connection with Mr. Noble's paper on elasticity, I think some experimental work done about three years ago at the Bull Run Dam will be of interest. In this study some variables other than those emphasized in Mr. Noble's paper were studied. Dealing with different combinations of the same materials, it was found that there was no universal relationship between strength and the modulus of elasticity. For example, it was possible to produce different mixtures of concrete having the same modulus of elasticity but having strengths differing as much as 100 per cent. This was accomplished by such manipulation of the size and gradings of the aggregates and the richness of the mixes as would cause wide variation in the paste content with only minor variation in the water-cement ratio.

Earlier investigators were able to find a relationship between elasticity and strength because, I believe, the tests were nearly always carried out with a series of mixtures in which the various factors affecting elasticity changed in an orderly manner and in the same direction as the change in strength. When, however, the series of mixtures are such that the paste content of the concrete bears no orderly relation to the strength, there will be no orderly relationship between strength and elasticity.

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[1] Associate Engineer, Portland Cement Assn., Chicago, Ill.

These findings, together with the results of Mr. Noble's work showing the important influence of different types of aggregates, make it apparent that precise knowledge of the elastic properties of a certain concrete mixture can be had only by direct test on that particular mixture.

APPENDIX VIII

SUGGESTED TERMINOLOGY APPLYING TO THE STUDY OF CONCRETE STRUCTURES IN SERVICE

By F. R. McMillan[1]

Construction Joint.—A surface of separation in a structure introduced during the process of construction; such joints may or may not be indicated on the plans.

Expansion Joint (sometimes called Contraction Joint).—Definite surface of separation in a structure designed to provide for expansion and contraction. Such joints are usually indicated in detail on the plans.

Fill Planes.—Irregular surfaces between sections of concrete deposited one above the other at different times. Usually horizontal or approximately horizontal, although sometimes inclined at a considerable angle.

Incrustation.—A deposit consisting chiefly of calcium carbonate formed on the surface of concrete by the carbonation of calcium hydroxide which is dissolved from the concrete by percolating water.

Efflorescence.—A water soluble deposit on the surface of concrete, formed by evaporation.

Disintegration:

Two forms of disintegration are recognized:

(*a*) *Concrete Disintegration.*—A gradual disruption or breaking down of the concrete mass itself, from any cause whatsoever. As examples of concrete disintegration, the following may be cited: Breaking down of the mass due to freezing of entrapped moisture, or the disintegration of the aggregates, or the disruption or loss of cementing value of the paste by solution or chemical action.

(*b*) *Structural Disintegration.*—Localized disruption of a concrete structure in which the concrete itself may not be disintegrating. Familiar examples of this are the disruption which follows corrosion of the reinforcement, and spalling at improperly designed expansion joints.

Deterioration.—This term should be used to describe a structure or concrete which is beginning to show the effects of weathering or other destructive agencies, but in which the effect has not progressed to the point where the term "disintegration" properly applies.

Failures.—Very few structures can be referred to as failures even though considerable deterioration or disintegration has resulted. This term should be reserved only for those cases where the conditions have developed almost to the point where the structure can no longer perform the services intended. If the structure can be repaired, it is not strictly a failure. It is only when complete rebuilding or replacement is necessary that this term properly applies.

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[1] **Director of Research, Portland Cement Assn., Chicago, Ill.**

Raveling (*or Unraveling*).—A type of concrete disintegration in which the coarse aggregate particles are loosened, due to disruption of the mortar or loss of bond.

Scaling.—A form of concrete disintegration affecting only the concrete at and near the surfaces. The following types are recognized:

(*a*) *Manipulation Scale.*—That occurring in thin layers of uniform depth at horizontal finished surfaces. Characterized by the complete absence of all aggregate particles except the extreme fines. This type of scale is due to excessive working or troweling and is usually not progressive as regards depth.

(*b*) *Frost Scale.*—That occurring in layers of irregular depth resulting from freezing of the surface before the concrete has thoroughly hardened.

(*c*) *Progressive Scale.*—A surface disintegration which continues to develop with time. Distinguished from general disintegration in that the interior of the mass remains sound. Results from continued surface attack by external agencies.

Exfoliation.—A type of disintegration consisting of a splitting off of thin sheets of concrete, usually curved, at either edges or corners, due apparently to unequal volume change. Characterized by general absence of coarse aggregate particles.

Spalling.—Breaking off of pieces or spalls usually of sound concrete irregular in shape and thickness, caused by expansive forces within the mass, such as corrosion of reinforcement of disruption of unsound aggregate.

Popping.—A localized type of spalling which occurs at a concrete surface. Usually limited to that caused by expansion of a piece of aggregate, either from moisture or temperature change, or by a swelling of a lump of clay or a piece of wood.

Cracks.—Cracks in structures may be divided into several classes depending upon the location and cause. The following causes of cracks are readily indentified in most cases:

(*a*) *Structural Cracks.*—Those which are in some way related to the structural service. They may be the result of stress, inadequate reinforcement, overloading, settlement, or some extraneous force not anticipated in the design. Except as they are sometimes coincident with shrinkage cracks, it is generally quite easy to identify cracks of this kind.

(*b*) *Shrinkage Cracks.*—Cracks occurring in a structure due to the normal shrinkage which may be expected of concrete. Their location, distribution, and size are determined by the amount and distribution of the reinforcement, size and arrangement of members, spacing of joints, and the character of the concrete.

(*c*) *Checking.*—A rather indefinite term. This term is usually applied to a large irregular type of crack which occurs in a mass of concrete during the plastic state or in the first few hours of the hardening period. They are generally not continuous and have no relation to any other feature of the structure or to cracks from other causes. They result from the rapid drying of the mass during the early period or a disturbance of the surface while in the plastic state.

(*d*) *Map Cracking.*—This refers to a type of crack which resembles irregular boundary lines of political subdivisions on a map. The most prominent example is the appearance of a mud flat, the surface of which has dried out. In describing map cracking in a structure, it is essential to indicate the general spacing, such as 2 in., 6 in., or 24 in., as they are likely to occur in almost any such spacing. The cracking of the rich mortar finish on a concrete floor and of thin, brushed or plastered coatings on walls are common forms of map cracking in small patterns.

(*e*) *Crazing.*—A form of surface shrinkage cracks of more or less uniform pattern. It is in effect a map cracking of small pattern.

Segregation.—A separation of the component materials of concrete during one or more of the operations incident to mixing, discharging, transporting and placing concrete. Refers to the segregation of the coarse aggregate from the mortar or of the water and lighter material from the mass in general. Segregation may be due to gross excess of water, poorly designed mix, improper mixing, insufficient length of mixing time, or improper methods of handling and placing.

Water Gain.—The segregation and accumulation of water in the upper portions of a layer of concrete resulting from overworking or excess mixing water. This is the result of one type of segregation.

Honeycomb.—A portion of a concrete mass from which the mortar or portions of the mortar have segregated, leaving large voids between the coarse aggregate particles. Results from the use of mixes containing insufficient mortar, or to loss of mortar through leaky forms or otherwise.

REPORT OF COMMITTEE C-10

ON

HOLLOW MASONRY BUILDING UNITS

Committee C-10 has held two meetings during the past year: in Atlantic City on June 25, 1930, and in Pittsburgh on March 19, 1931.

Proposed Specifications and Tests for Load-Bearing Concrete Masonry Units have been before the committee for over a year. They were discussed during three of the regular meetings of the committee and two separate drafts of proposed specifications have been submitted to all members for criticism. The requirements are based largely upon the results of experience with structures built to comply with municipal building codes and the results of a large number of strength and absorption tests of individual units. The committee has been benefited by its close contact with members of the American Concrete Institute who assisted in the preparation of specifications of that organization. Information on the strength and durability of masonry of hollow concrete units is not as complete as desired, but it is expected that additional data on these subjects will be obtained from investigations, now under way or contemplated, before the committee will recommend the adoption of specifications.

Two general revisions of the standards under the jurisdiction of this committee are being recommended, as follows:

The first of these revisions consists in the deletion of all portions of the standards pertaining to fire resistance requirements. At the time of their inclusion in the standards there were but few published data on the fire resistance of hollow tile masonry. It is considered that these requirements are no longer of value in the specifications because the information which they contain is given elsewhere now in more detail and completeness than is feasible in such a standard. They pertain to the properties of walls rather than of individual units and are of such a nature that no use is being made of them in connection with purchases of tile. The elimination of these requirements will not affect the other requirements, some of which were prepared after a consideration of the relations of the properties of individual units to the fire resistance of masonry.

The second revision deals with the designation of hollow clay building units now termed "hollow tile." A proposal to substitute the words "structural clay tile" for the expressions "hollow burned-clay tile" or "hollow tile" has been before the committee for about two and one-half years. The proposal originated with the Structural Clay Tile Association, an organization of manufacturers. When first made it was not approved by the committee largely because the new designation was not widely known or used. Since then considerable publicity has been given to the new designation in various ways including advertisements by some of the manufacturers. The committee is now of the opinion that the substitution of "structural clay tile" for "hollow burned-clay tile" or "hollow tile" not only will cause no serious confusion but that the new designation is a distinctly preferable one indicating as it does the use of the product.

RECOMMENDATIONS AFFECTING STANDARDS

Proposed Revisions of Standards.—The committee recommends that revisions in the following standards be referred to letter ballot of the Society by the necessary nine-tenths vote at the annual meeting for immediate adoption as standard:

Standard Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 – 30):[1]

Title.—Change the title from its present form to read as follows by the addition of the italicized word and the omission of the words in brackets:

> Standard Specifications and Tests for *Structural* [Hollow-Burned] Clay Load-Bearing Wall Tile.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

> 1. These specifications apply to *structural clay* [hollow] load-bearing wall tile made from surface clay, shale, fire clay or admixtures thereof.

Section 6.—Delete this section covering fire resistance requirements which reads as follows, renumbering the remaining sections accordingly:

> **6.** The tile shall meet the following requirements as tested according to the Tentative Specifications for Fire Tests of Building Constrution and Materials (A.S.T.M. Designation: C 19 – 26 T) of the American Society for Testing Materials as they apply for bearing walls and partitions and to be acceptable shall develop the following resistance period as tested unplastered:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 272.

THICKNESS OF WALL, IN.	NUMBER OF UNITS IN WALL THICKNESS	NUMBER OF CELLS IN WALL	RESISTANCE PERIOD, HOURS[a]
8	1	2	1½
8	1	3	2
12	1	3	3
12	2	3	4
12	2	4	5
16	2 or 3	4	6
16	2 or 3	6	8

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[a] These are near the minimum values developed in tests. The average results will generally be higher. Plaster coatings ¾ in. thick applied on both sides and remaining in place throughout the fire test will increase the periods by 1 to 2 hours.

Section 14.—Change the last two sentences to read as follows by the omission of the sentence and words in brackets:

[For the fire test the size of the test panel will govern the number of tile required.] Samples for the freezing tests shall be taken from tile that have not been subjected to strength [or fire] tests.

Section 15.—Change the last sentence to read as follows by the addition of the italicized figures and the omission of the words and figures in brackets:

If the [fire or] freezing tests are to be made it shall be so specified at the time of placing the order, samples [for fire tests] being selected at the factory *90* [at least 45] days in advance of the time of filling the order [and 90 days in advance for freezing tests].

Standard Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 – 30):[1]

Title.—Change the title from its present form to read as follows by the addition of the italicized word and the omission of the words in brackets:

Standard Specifications and Tests for *Structural* [Hollow-Burned] Clay Fireproofing Partition and Furring Tile.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

1. These specifications apply to *structural clay* [hollow] fireproofing, partition and furring tile made from surface clay, shale, fire clay or admixtures thereof.

Section 3 (b).—Change to read as follows by the addition of the italicized words:

(*b*) A tolerance of 5 per cent *under and 12.5 per cent over* will be allowed on the above standard weights.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 278.

Section 5.—Delete this section covering fire resistance requirements which reads as follows, renumbering the remaining sections accordingly:

> 5. In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (A.S.T.M. Designation: C 19 - 26 T) of the American Society for Testing Materials may be conducted by the purchaser.

Section 8.—Change the second sentence by the omission of the word "hollow."

Section 10.—Change Paragraph (*b*) by the omission of the words "fire resistance."

Section 13.—Change this section by the omission of the last sentence which reads as follows:

> For the fire test the size of the test panel will govern the number of tile required.

Section 14.—Change this section by the omission of the last sentence which reads as follows:

> If the fire tests are to be made, it shall be so specified at the time of placing the order, samples being selected at the factory at least 45 days in advance of the time of filling the order.

Standard Specifications and Tests for Hollow Burned-Clay Floor Tile (C 57 - 30):[1]

Title.—Change the title from its present form to read as follows by the addition of the italicized word and the omission of the words in brackets:

> Standard Specifications and Tests for *Structural* [Hollow-Burned] Clay Floor Tile.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

> 1. These specifications apply to *structural clay* [hollow] floor tile made from surface clay, shale, fire clay or admixtures thereof.

Section 3 (a).—In the title of the last table in this paragraph change the words "hollow tile" to read "structural clay tile."

Section 5.—Delete this section covering fire resistance requirements which reads as follows, renumbering the remaining sections accordingly:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 282.

5. In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (A.S.T.M. Designation: C 19 – 26 T) of the American Society for Testing Materials may be conducted by the purchaser.

Section 10.—Change Paragraph (*b*) by the omission of the words "fire resistance."

Section 13.—Change this section by the omission of the last sentence which reads as follows:

> For the fire test the size of the test panel will govern the number of tile required.

Section 14.—Change this section by the omission of the last sentence which reads as follows:

> If the fire tests are to be made, it shall be so specified at the time of placing the order, samples being selected at the factory at least 45 days in advance of the time of filling the order.

Standard Definitions of Terms Relating to Hollow Tile (C 43 – 24):[1]

The committee recommends that the present standard definitions be replaced by the proposed Revised Standard Definitions of Terms Relating to Structural Clay Tile, appended hereto.[2] The revisions in the definitions consist chiefly in substituting the words "structural clay tile" for the expressions "hollow burned-clay tile" and "hollow tile."

The above recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF STANDARDS			
Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 – 30):			
Change in Title, immediate adoption	21	1	2
Deletion of Fire Resistance Requirements, immediate adoption	23	1	0
Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 – 30), immediate adoption	20	2	2
Specifications and Tests for Hollow Burned-Clay Floor Tile (C 57 – 30), immediate adoption	22	1	1
Definitions of Terms Relating to Hollow Tile (C 43 – 24), immediate adoption	27	2	2

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 287.

[2] See 1931 Supplement to Book of A.S.T.M. Standards, p. 74.—ED.

This report has been submitted to letter ballot of the committee, which consists of 33 members; 29 members returned their ballots, of whom 28 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

D. E. PARSONS,
Chairman.

H. D. FOSTER,
Secretary.

EDITORIAL NOTE

The proposed immediate revisions of the Standard Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile, for Hollow Burned-Clay Fireproofing, Partition and Furring Tile, for Hollow Burned-Clay Floor Tile and of the Definitions of Terms Relating to Hollow Tile were approved at the annual meeting by a unanimous vote and subsequently adopted by letter ballot of the Society on September 1, 1931. The standards in their revised form appear in the 1931 Supplement to Book of A.S.T.M. Standards pages 43, 49, 53 and 74, respectively.

Subsequent to the annual meeting the committee approved proposed Tentative Specifications and Tests for Load-Bearing Concrete Masonry Units for submission to the Society through Committee E-10 on Standards. The specifications were accepted for publication as tentative on August 6 by Committee E-10 and appear on page 781.

REPORT OF COMMITTEE C-11
ON
GYPSUM

As has been the custom for a number of years, Committee C-11 on Gypsum met in the fall and also in the spring at the Bureau of Standards, Washington, D. C. The fall meeting was held on November 21, 1930, and the spring meeting on March 27, 1931. A third meeting will be held in Chicago, Ill., in conjunction with the annual meeting of the Society.

The committee was exceptionally unfortunate in losing one of its most valued members, Harry E. Brookby, who passed away November 15, 1930. Mr. Brookby was an officer of the committee and Chairman of Subcommittee I on Gypsum for Various Uses. He also served the committee for a number of years as Chairman of Subcommittee IV on Testing Methods. He took an exceptionally active part in the work of the committee and the committee feels a distinct loss in his passing.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Gypsum for Various Uses (H. J. Brown, chairman).—This subcommittee is continuing its investigations of the uses of gypsum and anhydrite as a retarder for portland cement and in this work has the very helpful cooperation of Paul S. Roller of the Non-Metallic Minerals Experiment Station of the Bureau of Mines, New Brunswick, N. J.

Subcommittee II on Gypsum Plasters (J. Miller Porter, chairman).—Subcommittee II is investigating the suitability of the modified vicat apparatus for determining the standard consistency of gypsum ready-sanded plaster and gypsum wood-fiber plaster. From the results so far obtained it looks very promising.

Because of the difficulty of storing standard Ottawa sand so as to keep its acceleration factor and the sand free from contamination, the committee has been investigating the use of a positive accelerator of standard composition to be used without sand in the determination of the time of set of neat plaster. Further investigations are being conducted.

Subcommittee III on Structural Gypsum Products (H. W. Reel, chairman).—This subcommittee has spent the entire year in testing gypsum-board products with the result that it recommends, as described below, revisions in the Standard Specifications for Gypsum Plaster Board (C 37 – 30), Standard Specifications for Gypsum Wall Board (C 36 – 25), and Tentative Specifications for Gypsum Sheathing Board (C 79 – 30 T).

Subcommittee IV on Testing Methods (C. K. Roos, chairman).—This subcommittee has very actively cooperated with Subcommittee II on Gypsum Plasters in outlining the method of conducting tests to determine the time of set of neat plaster and with Subcommittee III on Structural Gypsum Products in outlining the test procedure to be followed when testing gypsum board products. It is also engaged in the investigation of the method of determination of the sand content of set plaster.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The following recommendations are made relative to the standards and tentative standards under the jurisdiction of the Committee:

Standard Specifications for Gypsum Plaster Board (C 37 – 30).[1]—In view of the fact that the standard size of gypsum plaster board has been changed from 32 by 36 in. to 16 by 32 in. and 16 by 48 in., it is impossible to obtain a standard 12 by 18-in. specimen for the flexural strength test when the load is applied parallel to the grain in the paper surfacing on a span length of 16 in. Tests have accordingly been conducted on gypsum plaster board, gypsum wall board and gypsum sheathing board by members of the committee to determine the strength of the board using specimens 12 in. in width by 16 in. in length when placed on supports 14 in. apart as compared to the present specimen tested on the 16-in. span length. Based on these tests, the committee recommends that the size of test specimen be changed to 12 by 16 in. and that the flexural strength test be made on a span length of 14 in.

The gypsum industry has substituted the more definite term "gypsum lath" for the more general term "gypsum plaster board." The committee therefore recommends changing the term "gypsum plaster board" in the title of these specifications as well as in the body of the specifications to "gypsum lath."

These changes have been incorporated in the proposed Tentative Specifications for Gypsum Lath, appended hereto,[2] which the committee recommends for publication as a tentative revision of the present Standard Specifications for Gypsum Plaster Board (C 37 – 30). A clause has also been incorporated in the revised specifications requiring the specimens to be tested under specified temperature and humidity conditions.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 117.

[2] See p. 743.—ED.

Standard Specifications for Gypsum Wall Board (C 36 – 25).[1]—Tests similar to those conducted on gypsum plaster board as mentioned above were made on gypsum wall board, and the committee accordingly recommends similar revisions in these specifications. The revisions have been incorporated in the proposed Tentative Specifications for Gypsum Wall Board, appended hereto,[2] which the committee recommends for publication as a tentative revision of the present Standard Specifications for Gypsum Wall Board (C 36 – 25).

Standard Methods of Testing Gypsum and Gypsum Products (C 26 – 30).[3]—In order that the method of determining flexural strength of gypsum boards specified in these standard methods shall be in agreement with the test procedure prescribed in the proposed revised specifications for gypsum lath, gypsum wall board, and gypsum sheathing board, the committee recommends the following revision of the Standard Methods C 26 for publication as a tentative revision:

Section 27.—Change this section from its present form to read as follows:

27. (*a*) *Test Specimens.*—The test specimens shall be 12 in. (300 mm.) in width and approximately 16 in. (410 mm.) in length. The specimens shall be weighed to within 0.5 g. and then stored at a temperature of from 60 to 85° F. in an atmosphere of 25 to 50-per-cent relative humidity. The specimens shall be weighed once a day until the weight has become constant to within 0.1 per cent.

(*b*) *Procedure.*—The test specimen shall be centrally supported on fixed parallel bearings spaced 14 in. (350 mm.) between centers and the load-applying block brought in contact with the upper surface of the specimen midway between the supports. All bearings and load surfaces shall be true, shall engage the full width of the test specimen and shall be rounded to a radius of $\frac{1}{8}$ in. (3.2 mm.). The test load shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate.

(*c*) *Report.*—Flexural strength test results shall be reported with the load applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

Note.—Omit the present note at the end of Section 27, which reads as follows:

NOTE.—In testing gypsum boards of such narrow width that the longest dimension of the standard test specimen cannot be cut across the fiber of the surfacing, the strength test with knife edges parallel to the fiber of the surfacing may be omitted.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 114.
[2] See p. 740.—ED.
[3] 1930 Book of A.S.T.M. Standards, Part II, p. 125.

Tentative Specifications for Gypsum Sheathing Board (C 79 - 30 T).[1] —In order that these specifications shall be in harmony with the revised specifications for gypsum lath and gypsum wall board, the committee recommends that the proposed revised tentative specifications, appended hereto,[2] be accepted for publication as tentative to replace the present Tentative Specifications C 79 - 30 T.

Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 29 T).[3]—It is recommended that the definitions of the term "gypsum plaster board" and "gypsum wall board" be revised as follows, and that the definitions as revised be continued as tentative:

Gypsum Plaster Board.—Change from its present form: namely,

> *Gypsum Plaster Board.*—A sheet composed of an incombustible core of gypsum, surfaced with paper or other fibrous material which is firmly bonded to the core, or with intermediate layers of such material within the core, or an incombustible sheet of gypsum with not more than 15 per cent by weight of fiber intimately mixed; and designed to be used as a lath for the reception of gypsum plaster.

to read as follows:

> *Gypsum Plaster Board.*—A sheet or slab having an incombustible core of gypsum, containing not more than 15 per cent by weight of fiber, and surfaced with paper or other fibrous material firmly bonded to the core.

Gypsum Wall Board.—Change from its present form: namely,

> *Gypsum Wall Board.*—A sheet composed of an incombustible core of gypsum, surfaced with paper or other fibrous material which is firmly bonded to the core, and designed to be used, without the addition of plaster, for walls, ceilings, or partitions and affording a surface suitable to receive decoration.

to read as follows:

> *Gypsum Wall Board.*—A gypsum plaster board designed to be used, without the addition of plaster, for walls, ceilings, or partitions, and affording a surface suitable to receive decoration.

It is also recommended that the following definitions be added to the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 29 T):

> *Gypsum Lath.*—A gypsum plaster board, designed to be used as a base for the reception of gypsum plaster.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1019 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 172.

[2] See p. 746.—Ed.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 627 (1929); also 1930 Book of A.S.T.M. Tentative Standards, p. 175.

Gypsum Sheathing Board.—A gypsum plaster board, designed to be used as a sheathing in buildings.

Gypsum Concrete.—A combination of aggregate or aggregates with gypsum as a binding medium, which after mixing solidifies into a conglomerate mass.

Gypsum Fiber Concrete.—Gypsum concrete in which the aggregate consists of shavings or chips of wood.

The recommendations appearing in the report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE REVISIONS OF STANDARDS			
Standard Specifications for Gypsum Plaster Board (C 37 - 30)	24	0	5
Standard Specifications for Gypsum Wall Board (C 36 - 25)	24	0	5
Standard Methods of Testing Gypsum and Gypsum Products (C 26 - 30)	24	0	5
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Specifications for Gypsum Sheathing Board (C 79 - 30 T)	22	0	7
Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 29 T)	27	0	2

This report has been submitted to letter ballot of the committee, which consists of 31 members; 29 members returned their ballots, of whom 28 have voted affirmatively and none negatively.

Respectfully submitted in behalf of the committee,

J. W. GINDER,
Chairman.

H. J. SCHWEIM,
Secretary.

EDITORIAL NOTE

The proposed tentative revisions of the Standard Specifications for Gypsum Plaster Board and for Gypsum Wall Board, in the form of new tentative specifications entitled Tentative Specifications for Gypsum Lath and Tentative Specifications for Gypsum Wall Board, respectively, were accepted for publication as tentative and appear on pages 743 and 740. The proposed tentative revision of the Standard Methods of Testing Gypsum and Gypsum Products was also accepted for publication as tentative and appears on page 1058.

The proposed revisions of the Tentative Specifications for Gypsum Sheathing Board and of the Definitions of Terms Relating to the Gypsum Industry were accepted. The specifications and definitions in their revised form appear on pages 746 and 749, respectively.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held a meeting at Indianapolis, Ind., on April 2, 1931.

Since the last annual meeting 14 new members have been elected and 11 resignations have been accepted, leaving a total membership of 184.

At a meeting of the committee held during the annual meeting of the Society at Atlantic City in June, Subcommittee XXV on Cellulose Ester Coatings presented revisions of three tentative standards, namely, Tentative Specifications for Amyl Alcohol (Synthetic) (D 319 – 30 T); Specifications and Tests for Soluble Nitrocellulose (D 301 – 30 T) and Methods for Sampling and Testing Lacquer Solvents and Diluents (D 268 – 30 T) which had been prepared by the subcommittee too late for inclusion in the 1930 report. Due to the need for keeping the specifications and tests for such materials, which are essentials in the lacquer industry, up-to-date, Committee D-1 referred these revisions to Committee E-10 on Standards for publication as tentative.[1] The revisions as recommended by the committee were approved by Committee E-10 on August 12, 1930. The tentative standards in their revised form appear in the 1930 Proceedings.[2]

The work of the committee has progressed in a satisfactory manner along the many lines of activity over which the committee has jurisdiction and the work of the past year has resulted in the following recommendations:

I. Three new tentative specifications, and two new tentative methods of test are being submitted;

II. Revisions for immediate adoption are proposed in two standard specifications;

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[1] In submitting the revisions to Committee E-10 the committee reported the following results of the letter ballot vote from a total of 73 ballots returned: Tentative Specifications for Amyl Alcohol (Synthetic) (D 319 – 30 T), 56 affirmative, none negative with 17 members not voting; Tentative Specifications and Tests for Soluble Nitrocellulose (D 301 – 30 T), 51 affirmative, none negative with 22 members not voting; Tentative Methods for Sampling and Testing Lacquer Solvents and Diluents (D 268 – 30 T), 58 affirmative, 1 negative with 14 members not voting.

[2] See *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1079, 1067 and 1085, respectively (1930).

III. The revision of one tentative specification and one tentative method of test is proposed;

IV. The advancement to standard of six tentative specifications and three tentative methods of test is proposed.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

In this report, recommendations affecting standards and tentative standards are noted in brief form together with the results of the letter ballot. These recommendations are explained in greater detail in the reports of the subcommittees which are directly responsible for them.

I. *Proposed Tentative Standards.*—The committee submits for publication as tentative, the following three new specifications and two new methods of test as appended hereto:

Proposed Tentative Specifications for Acetone,[1] recommended by Subcommittee XXV;

Proposed Tentative Specifications for Beta Ethoxy Ethanol (Synthetic)[2], recommended by Subcommittee XXV;

Proposed Tentative Specifications for Beta Butoxy Ethanol (Synthetic)[2] recommended by Subcommittee XXV;

Proposed Tentative Method of Test for the Tinting Strength of White Pigments,[3] recommended by Subcommittee VIII;

Proposed Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels,[4] recommended by Subcommittee XXV.

II. *Proposed Revisions of Standards.*—The committee recommends that the following two standard specifications be revised as given in detail in the report of Subcommittee XV and continued as standard. The committee accordingly asks for the necessary nine-tenths vote for immediate adoption:

Standard Specifications for Red Lead (D 83 - 24);

Standard Specifications for Basic Carbonate White Lead (D 81 - 24).

III. *Proposed Revisions of Tentative Standards.*—The committee recommends that the following tentative specifications and tentative methods of test be revised as given in detail in the report of Subcommittee XXV and continued as tentative:

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[1] See p. 796.—ED.

[2] These specifications cover materials which involve patents and were accordingly referred to the Executive Committee. See Editorial Note, p. 446.—ED.

[3] See p. 797.—ED.

[4] See p. 806.—ED.

Tentative Specifications and Tests for Soluble Nitrocellulose (D 301 - 30 T);

Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 - 30 T).

IV. *Advancement to Standard of Tentative Standards.*—The committee recommends that the following tentative specifications and methods of test, with revisions as noted in the reports of the subcommittees, be advanced to standard:

Tentative Specifications for Aluminum Powder for Paints (Aluminum Bronze Powder) (D 266 - 28 T), as proposed by Subcommittee XV;

Tentative Specifications for Gold Bronze Powder (D 267 - 28 T), as proposed by Subcommittee XV;

Tentative Specifications for the Toxic Ingredients in Anti-Fouling Paints (D 277 - 28 T), with revision, as proposed by Subcommittee XXIII.

Tentative Method of Test for Alkalinity or Acidity of Pigments (D 278 - 28 T), as proposed by Subcommittee VIII;

Tentative Methods of Test for Bleeding of Pigments (D 279 - 29 T), as proposed by Subcommittee VIII;

Tentative Methods of Test for Hygroscopic Moisture (and Other Matter Volatile under the Test Conditions), in Pigments (D 280 - 28 T), as proposed by Subcommittee VIII;

Tentative Method of Routine Determination of Acetone Extract in Dry Lampblack and Dry Bone Black (D 305 - 29 T), as proposed by Subcommittee VIII;

Tentative Method of Test for Determination of Polishing Lubricant in Aluminum Powder for Paints (Aluminum Bronze Powder) (D 306 - 29 T), as proposed by Subcommittee VIII;

Tentative Method of Test for Oil Absorption of Pigments (D 281 - 28 T), with revision, as proposed by Subcommittee VIII.

V. *Tentative Standards Continued as Tentative.*—In addition to the recommendations affecting the tentative standards mentioned in this report, there are a number of additional tentative standards under the jurisdiction of the committee not specifically mentioned in the report or in the subcommittee reports. Special conditions are responsible for the continuance of but one of these tentative standards beyond the three year limit, and the committee recommends that these tentative standards be continued without revision.

The above recommendations have been submitted to letter ballot of the committee, which consists of 184 members; 56 members returned their ballots. The analysis of the vote of the committee is given below:

Items	Affirmative	Negative	Not Voting
I. NEW TENTATIVE STANDARDS			
Specifications for Acetone	35	1	20
Specifications for Beta Ethoxy Ethanol (Synthetic)	32	2	22
Specifications for Beta Butoxy Ethanol (Synthetic)	33	2	21
Method of Test for the Tinting Strength of White Pigments	35	7	14
Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels	35	1	20
II. PROPOSED REVISIONS OF EXISTING STANDARDS			
Specifications for Red Lead (D 83 – 24), immediate adoption	40	0	16
Specifications for Basic Carbonate White Lead (D 81 – 24), immediate adoption	39	1	16
III. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Specifications and Tests for Soluble Nitrocellulose (D 301 – 30 T)	36	0	20
Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 – 30 T)	33	1	22
IV. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Specifications for Aluminum Powder for Paints (Aluminum Bronze Powder) (D 266 – 28 T)	38	0	18
Specifications for Gold Bronze Powder (D 267 – 28 T)	36	0	20
Specifications for the Toxic Ingredients in Anti-Fouling Paints (D 277 – 28 T), as revised	32	0	24
Method of Test for Alkalinity or Acidity of Pigments (D 278 – 28 T)	40	0	16
Methods of Test for Bleeding of Pigments (D 279 – 29T)	40	0	16
Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 – 28 T)	40	0	16
Method of Routine Determination of Acetone Extract in Dry Lampblack and Dry Bone Black (D 305 – 29 T)	38	0	18
Method of Test for Determination of Polishing Lubricant in Aluminum Powder for Paints (Aluminum Bronze Powder) (D 306 – 29 T)	36	0	20
Method of Test for Oil Absorption of Pigments (D 281 – 28 T), as revised	41	1	14

ACTIVITIES OF SUBCOMMITTEES

Appended hereto are reports of the following subcommittees:

Subcommittee VIII on Methods of Analysis of Paint Materials;
Subcommittee XV on Specifications for Pigments Dry and in Oil when Marketed in that Form;
Subcommittee XXV on Cellulose Ester Coatings; and
Joint Committee on Protective Coating Research.

In addition to the subcommittee reports appended, the activities of other subcommittees are reported as follows:

Report of Subcommittee III on Testing of Paint Vehicles (H. A. Gardner, chairman).—Because of the growing interest in domestic tung oil and because of new ideas regarding some of the tests, this subcommittee recommends the continuance of the Tentative Specifications for Raw Tung Oil (D 12 – 25 T) and for Soya Bean Oil, Raw or Refined (D 124 – 22 T) as tentative.

Report of Subcommittee V on Linseed Oil (R. D. Bonney, chairman).—This subcommittee has received several criticisms of the Tentative Specifications for Boiled Linseed Oil (D 260 - 28 T) during the past year and it recommends the continuance of these specifications as tentative, pending the completion of such work as is necessary to determine whether any changes should be made.

Report of Subcommittee VI on Definitions (D. W. Edgerly, chairman).—This subcommittee is actively considering a large number of definitions and it is planned that a number of revisions or additions will be made to the Standard Definitions of Terms Relating to Paint Specifications (D 16 - 24) in the near future. It is accordingly recommended that the tentative revision of these definitions be continued.

Report of Subcommittee VII on Accelerated Tests for Protective Coatings (H. A. Nelson, chairman).—This subcommittee has decided to proceed with accelerated tests on the standard type of edge grain, western red cedar which has been adopted temporarily as the most satisfactory type of wood. Experiences with accelerated weathering equipment have been reported by several laboratories and an effort will have to be made to try to crystallize some specific recommendations from the large mass of seemingly conflicting data which is now available. The subcommittee has continued its policy of seeking by every means to encourage the publication of data on accelerated weathering tests in an effort to make available to all who are interested, as much of the technical information on this subject as possible.

Report of Subcommittee XIII on Shellac (J. W. Paisley, chairman).—This subcommittee has done considerable work during the past year on Tentative Methods of Sampling and Testing Shellac (D 29 - 29 T) and it recommends that these methods, as well as the Tentative Specifications for Dry Bleached Shellac (D 207 - 29 T) and Tentative Specifications for Orange Shellac (D 237 - 29 T), be continued as tentative.

Report of Subcommittee XXIII on Anti-Fouling Paints (A. M. Muckenfuss, chairman).—This subcommittee recommends that the Tentative Specifications for the Toxic Ingredients in Anti-Fouling Paints (D 277 - 28 T)[1] be revised as indicated below, and that the specifications, as revised, be advanced to standard:

Section 2(a).—Change the requirement for cuprous oxide content from "90 per cent" to read "96 per cent."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 872 (1928); also 1930 Book of A.S.T.M. Tentative Standards, p. 267.

This report has been submitted to letter ballot of the committee, which consists of 184 members; 56 members returned their ballots, of whom 53 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

P. H. CATHCART,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Acetone, the Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels and Method of Test for Tinting Strength of White Pigments were accepted for publication as tentative and appear on pages 796, 806 and 797, respectively.

The proposed Tentative Specifications for Beta Ethoxy Ethanol (Synthetic) and for Beta Butoxy Ethanol (Synthetic) which covered materials that involved patents were accepted for publication as tentative subject to review by the Executive Committee of the Society in respect to patent features. The specifications are still under consideration by the Executive Committee and have accordingly not been published as tentative.

The proposed immediate revision of the Standard Specifications for Red Lead and Specifications for Basic Carbonate White Lead were approved at the annual meeting by a unanimous vote and subsequently adopted by letter ballot of the Society on September 1, 1931. The standards in their revised form appear in the 1931 Supplement to Book of A.S.T.M. Standards, pages 78 and 76, respectively.

The proposed revisions of the Tentative Specifications and Tests for Soluble Nitrocellulose and of the Methods of Sampling and Testing Lacquer Solvents and Diluents were accepted. The specifications and methods in their revised form appear on pages 785 and 799, respectively.

The Tentative Specifications for the Toxic Ingredients in Anti-Fouling Paints, as revised, for Aluminum Powder for Paints (Aluminum Bronze Powder), for Gold Bronze Powder, and Method of Test for Oil Absorption of Pigments, as revised, Test for Alkalinity or Acidity of Pigments, Test for Bleeding of Pigments, Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments, Routine Determination of Acetone Extract in Dry Lampblack and Dry Bone Black, and Test for Determination of Polishing Lubricant in Aluminum Powder for Paints (Aluminum Bronze Powder) were approved for reference to letter ballot of the Society for adoption as standard. The specifications and methods in their revised form appear in the 1931 Supplement to Book of A.S.T.M. Standards, pages 82, 80, 81, 91, 84, 85, 88, 92 and 93, respectively.

REPORT OF SUBCOMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS

No criticisms having been received, the subcommittee recommends that the following tentative standards be advanced to standard:

Tentative Method of Test for Alkalinity or Acidity of Pigments (D 278 - 28 T);[1]

Tentative Methods of Test for Bleeding of Pigments (D 279 - 29 T);[2]

Tentative Methods of Test for Hygroscopic Moisture (and Other Matter Volatile Under the Test Conditions) in Pigments (D 280 - 28 T);[1]

Tentative Methods of Routine Determination of Acetone Extract in Dry Lampblack and Dry Bone Black (D 305 - 29 T);[2]

Tentative Methods of Test for Determination of Polishing Lubricant in Aluminum Powder for Paints (Aluminum Bronze Powder) (D 306 - 29 T);[2]

Tentative Method of Test for Oil Absorption of Pigments (D 281 - 28 T)[1] with the addition of the following as Note 1 renumbering the remaining notes and references to Notes in Section 1, accordingly:

> NOTE 1.—The weight of sample depends upon the specific gravity, fineness, and other characteristics of the pigment. For example, if 20 g. is taken for white lead, about 1 g. is sufficient for carbon black. In any event the size of sample should be large enough so that at least 1 g. of oil is required.

The cooperative study on the determination of the tinting strength of pigments was continued during the past year. A summary prepared from the reports of the cooperators is appended. As a result of these studies, the subcommittee submits herewith a Proposed Tentative Method of Test for Tinting Strength of White Pigments[3] and recommends it for publication as tentative.

The subcommittee plans to carry out during the coming year cooperative tests on methods of determining the hiding power of paints and pigments.

Respectfully submitted on behalf of the subcommittee,

F. W. SMITHER,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, pp. 877, 881, 884 (1928); also 1930 Book of A.S.T.M. Tentative Standards, pp. 287, 291, 294.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, pp. 652, 675, 676 (1929); also 1930 Book of A.S.T.M. Tentative Standards, pp. 288, 317, 318.

[3] See p. 797.—ED.

APPENDIX

REPORT OF COOPERATIVE WORK ON THE DETERMINATION OF THE TINTING STRENGTH OF PIGMENTS

The investigation on tinting strength, reported herein, carried on in cooperation with the work of Subcommittee VIII on Methods of Analysis of Paint Materials, is a continuation of the studies reported on at the 1930 annual meeting.[1] The work during the past year has been devoted to cooperative tests with the tinting strength method developed in the laboratories of the National Lead Co. Reports have been submitted by the following organizations:[2] U. S. Bureau of Standards, Henry A. Gardner Laboratory, New York City Central Testing Laboratory, New Jersey Zinc Co. Research Laboratories, E. I. du Pont de Nemours and Co., Ault & Wiborg Varnish Works, R. T. Vanderbilt Co., and the National Lead Co.

TABLE I.—RESULTS OF TINTING STRENGTH TESTS BY NATIONAL LEAD CO. METHOD.[a]

	White Lead	Zinc Oxide	Lithopone	Titanium Lithopone	Titanox B	Cryptone	Titanox C	Zinc Sulfide	Titanium Oxide
Bureau of Standards	127	222	285	399	380	443	475	633	1248
Gardner Laboratory	129	212	283	437	380	489	482	687	1158
N. Y. City Laboratory	126	241	291	386	380	424	456	602	1191
N. J. Zinc Co	146	234	291	391	380	443	457	671	1140
Du Pont Co	137	242	293	398	380	443	473	624	1151
Ault & Wiborg	143	174	301	412	380	456	475	570	1267
Vanderbilt Co		228	310	380	380	411	494	665	1170
National Lead Co.[b]	105	210	300	350	380	450	460	610	1200
Titanium Co., N. Y., No. 1[b]	105	200	270	350	380	430	470	560	1140
Titanium Co., N. Y., No. 2[b]	100	220	270	360	380	430	470	570	1150
Titanium Co., St. Louis	125	220	280	380	380	460	490	600	1225
Average, all laboratories	124	218	289	386	380	443	473	617	1185
Maximum Deviation from Average, per cent	19	20	7	13	..	11	4	11	7
Number of Results Over 5 per cent from Average	6	5	3	4	..	2	0	6	2
Number of Results Over 11 per cent from Average	6	1	0	1	..	0	0	0	0

[a] All results calculated to Titanox B = 380.

[b] These laboratories were accustomed to judging comparative tints with both white lead and Titanox B standards which may account for their lower figures on white lead.

Ten laboratories in all determined the tinting strengths of the nine pigment samples that were distributed, three of these being the laboratory of the National Lead Co. and two laboratories, Nos. 1 and 2 of the Titanium Pigment Co. who were accustomed to the method.

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[1] See *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 748 (1930).

[2] The Pratt and Lambert Laboratory submitted a report stating that as they had included the National Lead Co.'s method in the previous work on tinting strength and hiding power, using six other pigment samples, it was considered unnecessary to again check it, using the new set of samples. For this reason it is not possible to include any results from that laboratory in the present summary.

The 1930 tests on tinting strength included only six pigments, and the results were calculated to basic carbonate white lead as 100. Three operators reported results by the *unmodified* A.S.T.M. former Tentative Method D 282 – 28 T.[1] The results showed the following:

	Zinc Oxide	Lithopone	Titanox	Zinc Sulfide	Titanium Oxide
Maximum	336	395	538	835	1450
Minimum	274	370	516	544	1053
Average	302	383	526	716	1280
Maximum Deviation from Average, per cent	11	3	2	24	18

In the 1930 tests four operators reported results obtained by the "Preferred Laboratory Practice" in each laboratory. The results, calculated to basic carbonate white lead as 100, showed the following:

	Zinc Oxide	Lithopone	Titanox	Zinc Sulfide	Titanium Oxide
Maximum	172	232	291	435	838
Minimum	100	150	180	300	600
Average	140	196	261	383	721
Maximum Deviation from Average, per cent	29	23	31	22	17

Comments which accompanied the 1931 reports are as follows:

Ault & Wiborg Varnish Works: "In making our tests we noticed that while the Titanox B, chosen as standard, produces with the standard tinting black a bluish-gray; six out of eight of the samples of white pigments that were to be compared produced a greenish-gray, which is not easily compared with the blue-gray in getting the exact match for tinting strength. Would it not be better to choose as the standard white pigment, one that gives more of the greenish cast? For instance, zinc oxide gives the cleanest bluish-gray and Dutch process white lead the yellowish-gray; perhaps a mixture of three parts of white lead, to one of zinc oxide might be considered as a suitable standard, provided the mixture could be made with sufficient uniformity and accuracy."

R. T. Vanderbilt Co.: This laboratory hesitated to give a figure for white lead because of the wide difference in tint obtained when a standard gray paste was made. Further comments were:

"Frankly, our personal preference is still for the use of ultramarine blue and our opinion is that your method or the ultramarine blue method can be accurately standardized for the determination of tinting strength on various samples of any particular pigment, such as zinc oxide or titanox, but that owing to the different shades of gray or of blue which are obtained, either of these methods is only an approximation in comparing one pigment with another.

"We believe that Subcommittee VIII on Methods of Analysis of Paint Materials is in a position to recommend a standardized tinting strength method for any particular pigment but that it should not go on record as advocating any method for determining the relative tinting strength values of two different white pigments."

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[1] The former Tentative Method of Test for Mass Color and Tinting Strength of Pigments (D 282 – 28 T), since discontinued, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 885 (1928).

New York City Central Testing Laboratory: This laboratory commented on the method as follows: "(1) The consistency of all the pastes made as described appeared to be equal to the standard. (2) In order to avoid the entrance of light from below by transmission through the edges of the glass square and reflection from the lower inner surface, a dull black cloth was found necessary in matching the pastes. It is suggested, therefore, that black glass squares be used. (3) In nearly every case the hue was not the same as the standard, causing difficulty in obtaining an exact match. It is suggested that a suitable green glass be used for viewing the pastes in matching. (4) It was found unnecessary to prepare pastes for matching that differ from each other by less than 2 per cent of the black used, as the eye did not distinguish finer gradations."

E. I. du Pont de Nemours and Co.: "The operator's comments on the method may be summarized as follows: (1) Not enough sample is employed to permit a careful estimate of the consistency of the paste. A fraction of a drop of oil will make a considerable difference in the consistency and the brightness of the paste. (2) Increasing the pressure applied to the spatula during rubbing darkens the paste. No provision is made to keep the pressure constant as in the case of those methods employing a weighted, glass muller. Consequently it is difficult to make up duplicate pastes which will match exactly. (3) The use of only one standard which must be matched by trial makes the test time consuming, particularly when there is no previous estimate of the tinting strength for guidance.

One of the production laboratories of this company commented as follows:

"We are not favorably impressed by this testing method because it is not sufficiently accurate and it takes too long to complete the test on a sample. The inaccuracy is due largely to the use of carbon black as the tinting material. The carbon black gives different tints depending on the amount of grinding pressure employed in the test. Our previous experience has shown that the variation in apparent strength due to different amounts of mulling using lamp black as the tinting pigment was so great as to render the test hopeless as regards real accuracy.

"In our opinion, the practice of adjusting all pastes to the same consistency is open to serious question. It is well known that different amounts of oil tend to change the apparent strength. Consequently, we regard it as much fairer to test different samples of the same type of pigment with the same amount of oil. It is, obviously, impossible for the operator accurately to adjust all strength rub-outs to exactly the same consistency. Consequently, if he is allowed to use varying amounts of oil from one pigment to another, the tests will not be on the same basis either as regards a constant amount of oil or as regards a constant consistency. A minor source of error is the use of such a small amount of pigment which is more likely to allow errors to creep in.

"Finally, we would point out that a light spatula rubbing by no means duplicates the amount of grinding which is obtained in practical paint production. We believe that ultramarine blue is much superior to lamp black as a tinting material for a test of this type. On numerous occasions we have proved to our own satisfaction that the tint of a pigment-ultramarine-blue paste does not vary appreciably between spatula rubbing and three minutes' mulling with a weighted muller. On the basis of the above points, we are very strongly of the opinion that the described test is not well adapted for evaluation of the tinting strength of pigments."

U. S. Bureau of Standards: "Because of the great difference in the character of the tints between white lead and Titanox B, and Titanox C and Cryptone, matching by the unaided eye was difficult in these cases. Streaky pastes were obtained in a few cases (particularly noticeable when the paste was spread on a glass slide), and we should be interested to know whether others had this experience. We suggest that picking up and mixing the pastes at the end of the first and second minutes might improve this condition. This was not done in these rub-outs. Fresh lots of the standard gray titanox paste were made up at intervals, and the results indicate that good agreement of the brightness of the tint can be obtained by the method.

"We were unable to obtain a tinting strength of 100 for white lead, if the value of 380 is given to the standard gray Titanox B paste. Using the value 380 for titanox, this would call for $\frac{0.06 \times 100}{380} = 0.0158$ g. of black to use with the white lead, if the latter had a tinting strength of 100. We rubbed up 1.000 g. of the white lead and 0.0158 g. of the black, and obtained a brightness of the gray paste of nearly 22 per cent. Using 0.0200 g. of black, we obtained 20.4 per cent. Our ratio, therefore, arbitrarily calling white lead 100, is 300 for Titanox B. We should be interested to know if other cooperators agree with us.

"Some of the pigments are quite close together as regards tinting strength, and we shall be particularly interested in the relative positions of titanium lithopone, Cryptone, and Titanox C, as obtained by the other cooperators. These three pigments are stronger than Titanox B, and weaker than zinc sulfide. Titanium lithopone appears to be slightly stronger than Titanox B, but not as strong as Cryptone and Titanox C. Cryptone is stronger than titanium lithopone. Titanox C appears to be the strongest of these three. However, using the same amount of black for both Titanox C and Cryptone, the character of the tints is quite different. Titanox C gives a clear blue-gray, while Cryptone gives a muddy-gray. This made it very difficult to judge the relative position of these two with the unaided eye. This was evident from showing the two rub-outs to several observers in our paint laboratory.

"This is the first time we have used this spatula rub-out method. It appears simpler than mulling, and with repeated use, we could doubtless do better work with it. The amounts of oil used were read as closely as possible from a burette (graduated only to 0.1 ml.). However, the aim was to make pastes of approximately the same consistency in all cases, regardless of the burette readings."

Pratt & Lambert: This laboratory has done a lot of work comparing what were described as the preferred methods of several different companies in the previous cooperative work on tinting strength and hiding power with a modified plant procedure in which samples of different white pigments and pale alkali refined linseed oil in small pebble mills are ground until smooth pastes of the same consistency are obtained. These pastes are then tinted with a standard sample of lampblack ground in linseed oil, using a standard gray having a light reflection of approximately 20 per cent. They comment as follows:

"The average error with any method approximates 10 per cent; close checks are not obtained by two operators using the National Lead Co.'s method; closer checks are obtained by using the Pratt & Lambert method and the maximum error with any method is greater than should be tolerated. The method employed by the National Lead Co. offers a quick and simple means of determining the relative tinting strength of pigments. This method is no more accurate than several others employed in the industry. The method used by Pratt & Lambert is better suited to their needs than is the National Lead Co.'s method and is probably more accurate. The Pratt & Lambert method is not as rapid as the National Lead Co.'s method and not as well suited for comparing pigments of different oil absorption."

The letter of transmittal stated further that, "In view of the simplicity of the National Lead Co.'s method and the satisfactory results obtained with it, our results seem to indicate that this method is well adapted for adoption by the American Society for Testing Materials and general use in the industry."

REPORT OF SUBCOMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THAT FORM

During the past year, Subcommittee XV has given consideration to the various specifications under its jurisdiction and makes the following recommendations:

Standard Specifications for Red Lead (D 83 - 24).[1]—In some respects the Specifications for Red Lead have not been wholly consistent with respect to the requirements for coarse particles in the two grades of the pigment and in the dry pigment and paste. The subcommittee accordingly presents for immediate adoption the following revision in these specifications and recommends that the specifications as revised be continued as standard:

Section 3 (a).—In the table change the requirement for coarse particles retained on a No. 325 sieve for the 85-per-cent grade from the present value of "2.0 per cent" to read "1.0 per cent."

Standard Specifications for Basic Carbonate White Lead (D 81 - 24).[2]—The paste described in these specifications is the old-time material of quite stiff consistency. This variety is still needed, but softer paste which will mix more readily with paint thinners is now more largely used. To provide for these, the subcommittee presents the following revisions in these specifications for immediate adoption and recommends that the specifications as revised be continued as standard:

Section 1.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> 1. These specifications cover what is commonly known as basic carbonate white lead [as] used as a pigment and in putty, purchased either as dry pigment [or ground in oil to form a paste], *paste in oil, or semi-paste in oil.*

Section 2 (b) Paste.—Change this paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

> (b) Paste.—The paste shall be made by thoroughly grinding the specified pigment with [pure raw or refined] linseed oil *to a paste consistency.*

Add a new Paragraph (*c*) to this section to read as follows:

> (*c*) *Semi-Paste.*—The semi-paste shall be made by thoroughly grinding the specified pigment with linseed oil to a semi-paste consistency.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 311.

[2] *Ibid.*, p. 307.

Section 3 (*c*) *Paste.*—Change this paragraph to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(c) Paste.—The paste [as received] shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency.

The paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment [(as specified above)], per cent...	[92]	[90] *89.0*
Linseed oil, per cent....................	[10] *11*	[8]
Moisture and other volatile matter, per cent............................	0.7	..
Coarse particles and skins (total residue retained on a No. 325 sieve), per cent of the dry pigment................	1.5	..

Add a new Paragraph (*d*) to this section to read as follows:

(*d*) *Semi-Paste.*—The semi-paste shall not be caked in the container and shall be readily stirred to a uniform mixture which shall mix readily with oil to form a smooth paint of brushing consistency.

The semi-paste shall conform to the following requirements:

	MAXIMUM	MINIMUM
Pigment, per cent..............................	88	83
Linseed oil, per cent...........................	17	12
Moisture and other volatile matter, per cent........	0.7	..
Coarse particles and skins (total residue retained on a No. 325 sieve,) per cent of the dry pigment...	1.5	..

Tentative Specifications for Aluminum Powder for Paints (*Aluminum Bronze Powder*) (*D 266 – 28 T*) *and Tentative Specifications for Gold Bronze Powder* (*D 267 – 28 T*).[1]—These specifications have been tentative for three years without revision and since no further criticisms of them have been received, the subcommittee recommends that they be recommended to the Society for advancement to standard.

Many Prussian blues readily conform to the Standard Specifications for Prussian Blue (D 261 – 28) with respect to the requirement for water-soluble substances but some of the satisfactory iron blues now on the market, even when carefully and skillfully made, do not meet the specifications in this detail if tested by the standard methods of the Society. It appears probable that by this method some of the pigment itself may be dissolved. The subcommittee accordingly recommends that Subcommittee VIII on Methods of Analysis of Paint Materials investigate the matter.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, pp. 870 and 871 (1928); also 1930 Book of A.S.T.M. Tentative Standards, pp. 265 and 266.

The Tentative Specifications for Glazier's Putty (D 317 – 30 T) are still being studied. It is hoped to differentiate the varieties of putty more clearly. Meanwhile it is recommended that the specifications be continued as tentative.

Respectfully submitted on behalf of the subcommittee,

H. E. Smith,
Chairman.

REPORT OF SUBCOMMITTEE XXV ON CELLULOSE ESTER COATINGS

Subcommittee XXV held two meetings during the past year, one on January 12 and 13 at the Chemists' Club in New York City and the other on March 31, in Pittsburgh.

Subcommittee XXV wishes to express its appreciation of the valued help given by Mr. E. B. Smith during his many years of service on this subcommittee. In his passing the members of the subcommittee have lost a true friend.

The various groups of the subcommittee have been very active during the year and have prepared eight new specifications and one method of test, and have also reviewed the various tentative specifications and methods under the jurisdiction of the subcommittee which has resulted in a number of revisions which are being recommended in this report.

The subcommittee recommends for publication as tentative, as appended hereto, the following three specifications and one method of test. These specifications and methods of test have been prepared as a result of experience obtained in the plant manufacture and analyses of these materials for a great number of years:

Tentative Specifications for Acetone;[1]

Tentative Specifications for Beta Butoxy Ethanol (Synthetic);[2]

Tentative Specifications for Beta Ethoxy Ethanol (Synthetic);[2]

Tentative Methods of Testing Nitrocellulose Clear Lacquers and Lacquer Enamels.[3]

Tentative Specifications for Soluble Nitrocellulose (*D 301 – 30 T.*)[4]—The subcommittee recommends that these specifications be revised as follows and continued as tentative:

Section 6 (*b*).—Change the first sentence, of this paragraph to read as follows, by the addition of the italicized words and the omission of those in brackets:

> (*b*) Standardize the apparatus using c. p. potassium nitrate recrystallized [three times] *twice* from *distilled water and then washed with* 95 per cent ethyl alcohol, ground to pass a 100-mesh screen, and dried for 2 to 3 hours at 135 to 150° C.

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[1] See p. 796.—ED.

[2] These specifications cover materials which involve patents and were accordingly referred to the Executive Committee. See Editorial Note, p. 446.—ED.

[3] See p. 806.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1067 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 269.

Section 9.—Change the second sentence of the third paragraph to read as follows by the addition of the italicized words and the omission of those in brackets:

> The proper mixture is approximately one part [xylol] *toluol* and four parts [toluol] *xylol*, but the exact proportions must be determined by the "cut-and-try" method.

Section 10.—In the table change denatured alcohol to read as follows by the addition of the italicized words and the omission of those in brackets:

> Denatured alcohol, [commercially distilled] *completely denatured* (No. [1] *5*, [188] *188–190*-proof), per cent by weight.

Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 - 30 T).[1]—The subcommittee recommends that these methods be revised as follows and continued as tentative:

Section 4.—Delete the footnote to this section, which reads as follows:

> Tubes conforming to these requirements may be obtained from the New Jersey Laboratory Supply Co., Newark, N. J., their Catalog No. 22565.

Section 6.—Change the last sentence of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> The increase in the weight of the dish is the non-volatile matter of the sample, which should be expressed [as a percentage, calculating the weight of the sample from its specific gravity, determined as described in Section 3] *in grams per 100 ml.*

Section 9.—Change the last sentence in this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> The weight of the sample shall be determined from the specific gravity and the acidity reported as [percentage by weight of the appropriate acid, or as] milligrams of KOH per gram of sample *and in the case of esters the results are also to be expressed as a percentage by weight of the appropriate acid.*

Section 10.—Reletter the present section as Paragraph (*a*) and add the following test for alkalinity of acetone as a new Paragraph (*b*):

> (*b*) *Alkalinity of Acetone.*—To 100 ml. of acetone contained in a small Erlenmeyer flask, add 0.3 ml. of 0.01 N H_2SO_4 and 0.5 ml. of 0.3-per-cent aqueous paranitro phenol. The reaction shall not be alkaline to paranitro phenol.

Section 11.—In the second sentences of Paragraphs (*a*) and (*b*), change "0.5 N KOH" to read "0.5 N alcoholic KOH."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1085 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 312.

New Test Procedures.—Add the following test procedures for sulfur, dimethylketone and potassium permanganate test as new Sections 14 to 18:

14. *Sulfur (Hydrogen Sulfide and Sulfur Dioxide) in Benzols, Toluols, and Kindred By-Products.*—The qualitative test for hydrogen sulfide and sulfur dioxide shall be made at the time of performing the distillation test by hanging strips of moistened lead acetate paper and starch iodate paper on the end of the condenser tube. If the lead acetate paper shows discoloration, H_2S is present but not SO_2. In this case both papers will usually be discolored. If the lead acetate paper shows no discoloration but the starch iodate paper develops a blue color, SO_2 is present but not H_2S. If neither paper shows discoloration, neither H_2S nor SO_2 is present.

15. *Determination of Dimethylketone—Reagents.*—The following reagents will be required:

(*a*) *Sodium Thiosulfate* (0.05 *N*).—Sodium thiosulfate shall be made up and standardized carefully against $K_2Cr_2O_7$. For accurate work, standardized burettes shall be used and burette corrections and temperature corrections applied. The 50-ml. burettes with Bureau of Standards certificates are recommended, both for the standardization of solutions and for the actual determination of acetone.

(*b*) *Iodine* (0.1 *N*).—0.1 *N* iodine shall be made up and standardized at the time of making a determination. The standardization consists in titrating against the 0.05 *N* $Na_2S_2O_3$, 50 ml. of iodine mixed with the same amounts of NaOH and H_2SO_4 as are used in the determination of acetone. The titrations are made in triplicate and the average of the three with burette and temperature corrections is used as the blank in making the calculations.

(*c*) *Sodium Hydroxide.*—Normal NaOH shall be made up and standardized against 2 *N* H_2SO_4.

(*d*) *Sulfuric Acid.*—2 *N* H_2SO_4 shall be made up and checked against normal NaOH and the strength adjusted so that 25 ml. of the acid will neutralize 50 ml. of the NaOH.

(*e*) *Starch Solution.*—Stir up 2 to 3 g. of potato starch or 5 g. of soluble starch with 100 ml. of 1-per-cent salicylic acid solution, add 300 to 400 ml. boiling water, and boil the mixture until the starch is practically dissolved. Dilute to 1 liter.

16. *Preparation of Sample.*—Approximately 1.4 g. of acetone shall be carefully weighed by one of the following methods and made up to a volume of 1 liter:

(*a*) Glass ampules $\frac{5}{8}$ to $\frac{3}{4}$ in. in diameter shall be blown and after filling with acetone shall be sealed. The exact weight of sample shall be determined by the difference in weight of the empty and filled ampule. Samples varying in weight more than ±0.1 g. from 1.4 g. shall be rejected. The glass ampules shall be dropped into 500-ml. glass-stoppered bottles containing 200 ml. of boiled distilled water and broken by shaking. The capillary stem shall then be carefully crushed with a glass rod to allow thorough washing out of the acetone and the sample and combined washings made up to 1 liter at 20° C.

(*b*) A quick easy method is to weigh out 1.75 ml. of acetone from a 2-ml. pipette graduated in 0.1 ml. into a small glass-stoppered weighing bottle, conical shape, capacity 12 to 15 ml. This volume will weigh approximately 1.4 g. The weighing bottle shall be inverted and the mouth held under the surface of freshly boiled distilled water in a 1-liter beaker. The stopper shall then be removed under water by means of a glass rod with a hook on the end. The bottle shall be thoroughly washed out and the water and acetone transferred to a 1-liter flask and made up to the mark at 20° C.

17. *Procedure.*—Three 25-ml. aliquots from each of 3 flasks prepared in accordance with Section 16 (*a*) or (*b*) shall be pipetted into separate 750-ml. Erlenmeyer flasks containing 50 ml. each of the 1 N NaOH solution. A Bureau of Standards pipette shall be used for taking the samples from the flasks. Into each flask while shaking constantly shall be run 50 ml. of the 0.1 N iodine. The flasks shall then be stoppered and allowed to stand at about 20° C. (cooling necessary in warm weather) for at least 20 minutes. At the end of this time, 26 ml. of the 2 N H_2SO_4 shall be poured into the first flask which shall then be titrated immediately against 0.5 N $Na_2S_2O_3$. The solution shall be acid before any thiosulfate is added; otherwise, the determination will be ruined. When the color of the iodine has almost faded out, starch solution shall be added and the titration continued until the blue color disappears and the bright yellow color of the iodoform suspension is reached. The milliliters of thiosulfate shall be read, the burette and temperature corrections applied and the corrected reading subtracted from the average corrected blank. Percentage of dimethylketone by weight shall then be calculated from the following formula:

$$\text{Acetone, per cent by weight} = \frac{\begin{array}{c}(\text{milliliters of } Na_2S_2O_3 \text{ for blank} - \text{milliliters of}\\ Na_2S_2O_3 \text{ for sample}) \times N \times 0.9675 \times 40\end{array}}{\text{Weight of acetone taken for dilution}}$$

NOTE.—The following precautions shall be observed:

1. Only boiled distilled water shall be used in preparing the solutions and throughout the determination.

2. Standardized glassware shall be used and burette and temperature corrections shall be applied to all readings.

3. Weight of sample taken and amount of iodine solution used shall be as specified. With these amounts, the 35 to 40 per cent excess of iodine, found to be optimum for completion of the iodoform reaction will be present. Use of the small glass-stoppered bottle described in Section 16 (*b*) with the 2-ml. pipette insures uniformity in the weight of sample taken.

4. The iodine solution shall be added slowly and with constant shaking. The Bureau of Standards calibrated burette with fine tip and delivery time of approximately 2 minutes have been found very satisfactory.

5. A slight excess of acid shall be added just before the titration with thiosulfate. Too great an excess will give low results.

18. *Potassium Permanganate Test.*—To 100 ml. of acetone contained in a 250-ml. Erlenmeyer flask and maintained at 25° C., 1 ml. of 0.1-per-cent potassium permanganate solution shall be added with slight stirring.

REPORT OF JOINT COMMITTEE ON PROTECTIVE COATING RESEARCH

The principal activity of this joint committee[1] during the past half year has been an effort to acquaint university professors with the research possibilities in paint and varnish fields. This has been undertaken with a view to the working out of some of the fundamental problems facing the committee in the matter of thesis work by professors and graduate students for the master of arts degree or other graduate degrees.

With the cooperation of the *Journal of Industrial and Engineering Chemistry* and the editor of the American Chemical Society News Service, many professors of chemistry and chemical engineering have been contacted and much interesting work has been planned. During the past six months eighty-five individuals have requested copies of the "Survey of the Protective Coating Industry"[2] published last year. Of these eighty-five requests, twenty-one represented university professors of chemistry or chemical engineering.

The joint committee promises continued cooperation with those about to undertake problems in paint and varnish chemistry with a view not only to stimulating fundamental work but also in so far as possible in preventing duplication.

Respectfully submitted on behalf of the joint committee,

H. A. NELSON,
Representative of Committee D-1
on Joint Committee on Protective
Coating Research

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[1] Composed of representatives of the Paint and Varnish Division of the American Chemical Society, the Federation of Paint and Varnish Production Clubs, and Committee D-1 of the American Society for Testing Materials.

[2] *Circular No. 365* of the Scientific Section, Educational Bureau, American Paint and Varnish Manufacturers Assn., Issued June, 1930.

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants held three regular meetings during the past year (in June at Atlantic City, in January at Baltimore, and in March at Pittsburgh) and also an informal meeting in November in Chicago at the time of the annual meeting of the American Petroleum Institute.

The following subcommittees have been discontinued during the year:

I on Petrolatum;
X on Oxidation at High Temperatures;
XVIII on Gas Oil;
XIX on Illuminating Oils;
XXIV on Calorific Value;
XXVI on Petroleum Wood Preservatives;
Special Subcommittee with Committee D-7 on Timber to Cooperate with the American Wood Preservers Association on Petroleum Wood Preservatives; and
Special Subcommittee with Committee D-9 on Electrical Insulating Materials to Cooperate with the International Electro-Technical Commission on Methods of Sampling.

Acting as the Sectional Committee on Methods of Testing Petroleum Products and Lubricants, functioning under the procedure of the American Standards Association, the following recommendations in connection with American Standards and American Tentative Standards were made to bring these standards into conformity with the actions of the Society at the 1930 annual meeting.

Approval of Revised American Standards:

Method of Test for Burning Quality of Kerosine Oils (D 187 - 30) (A.S.A. No. Z 11*q* - 1930);
Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 30) (A.S.A. No. Z 11*s* - 1930);
Method of Test for Burning Quality of Mineral Seal Oil (D 239 - 30) (A.S.A. No. Z 11*r* - 1930);
Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (D 86 - 30) (A.S.A. No. Z 11*j* - 1930);

Method of Test for Distillation of Natural Gas Gasoline (D 216 – 30) (A.S.A. No. Z 11*k* – 1930);
Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30) (A.S.A. No. Z 11*b* – 1930);
Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 – 30) (A.S.A. No. Z 11*i* – 1930);
Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 – 30) (A.S.A. No. Z 11*h* – 1930).

Approval of Revised American Tentative Standards:
Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 30) (A.S.A. No. Z 11*e* – 1930).

Advancement of American Tentative Standard to American Standard:
Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline (D 130 – 30) (A.S.A. No. Z 11*u* – 1930).

Approval of A.S.T.M. Standards as American Tentative Standards:
Method of Test for the Determination of Autogenous Ignition Temperatures (D 286 – 30) (A.S.A. No. Z 11*w* – 1930);
Method of Test for Melting Point of Petrolatum (D 127 – 30) (A.S.A. No. Z 11*v* – 1930).

The above recommendations have since been approved by the American Standards Association with A.S.A. numbers as indicated.

The voting membership of Committee D-2 now consists of 38 producer, 33 consumer, and 10 general interest members.

ACTIVITIES OF SUBCOMMITTEES AND TECHNICAL COMMITTEES

Appended hereto are reports of the following:
Subcommittee XVI on Cloud and Pour Test;
Technical Committee A on Gasoline;
Technical Committee B on Motor Oils.

In addition, the activities of two other subcommittees are presented briefly as follows:

Subcommittee VIII on Distillation (E. W. Dean, chairman).—A suggestion to study the standardization of a method for vacuum distillation has been considered. It was generally agreed that vacuum distillation is a useful procedure as applied to plant control and to process developments but that at present it has no established significance as a test for the quality or suitability of finished products. For this reason the subcommittee recommends that no standardization program along this line be undertaken.

As mentioned later in the report, the subcommittee recommends the addition of a note of caution regarding the high-distillation thermometer specified in the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 30). The note originated in Committee D-15 on Thermometers.

Subcommittee XXI on Crude Petroleum (A. J. Kraemer, chairman).—Two lines of work are to be undertaken by this subcommittee during the coming year:

1. A study of the desirability of developing apparatus and procedure for the more or less complete evaluation of crude petroleum along the lines of the present Bureau of Mines' method. It is not the intention that this method will parallel or predict refinery yields, but that it will be a means for correlating analyses made by investigators in different laboratories, for their scientific value.

2. The determination or calculation of the gravity of crude petroleum on the dry (water-free) basis.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 - 30).[1]—The following change, proposed by Subcommittee V on Viscosity (W. H. Herschel, chairman), is recommended for publication as a tentative revision of this standard method:

Section 3 (b).—Change to read as follows by the addition of the italicized figures:

(*b*) With the Saybolt Furol Viscosimeter, determinations shall be made at 77, *100*, 122, or 212° F. (25, *37.8*, 50 or 100° C.).

Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 30).[2]—As an editorial change, the addition of the following cautionary note is recommended by Subcommittee VIII on Distillation (E. W. Dean, chairman):

Section 6 (b).—Add a note at the end of this paragraph to read as follows:

NOTE.—Under certain test conditions the bulb of the thermometer may be 50° F. (28° C.) above the temperature indicated by the thermometer, and at an indicated temperature of 700° F. (371° C.) the temperature of the bulb is approaching a critical range in the glass. It is therefore not desirable to use this thermometer under such conditions at indicated temperatures above 700° F. (371° C.) without checking the ice point.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 550.

[2] *Ibid.*, p. 491.

Standard Method of Test for Cloud and Pour Points of Petroleum Products (D 97 - 30).[1]—The following editorial changes to clarify the meaning are recommended by Subcommittee XVI on Cloud and Pour Test (J. B. Rather, chairman):

Title.—Delete the phrase "of Petroleum Products" from the title. This change in title is desirable since the method is used to some extent in the test of fatty oils not of petroleum origin.

Section 11.—In the seventh paragraph, change the last sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket *if the temperature of the oil is above 15° F., or directly in the cooling bath if the temperature is below 15° F.*, and [the same procedure] *a test for flow* repeated at the next temperature [reading] 5° F. lower.

Section 12 (a).—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

> 12. (*a*) In those cases where it is known that a sample has been subjected to some temperature higher than 115° F. during the preceding 24 hours, or where the history of the sample in this respect is not known, the sample shall be held in the laboratory 24 hours before testing, unless three consecutive tests of the same sample in the same test jar *give* check results. For these particular oils, [this] *results obtained by one or the other of the alternative procedures* shall be called the upper (maximum) pour point.

Standard Method of Test for Distillation of Natural Gas Gasoline (D 216 - 30)[2].—The following changes, proposed by Subcommittee XXII on Natural Gasoline (G. G. Oberfell, chairman), are recommended for publication as a tentative revision of the standard method:

Section 9.—Insert a new Paragraph (*d*) to read as follows and reletter the present Paragraphs (*d*), (*e*), and (*f*), accordingly:

> (*d*) A record shall be made of the room temperature at the time of each distillation. The heating apparatus including the shield and flask support shall be at room temperature at the start of each distillation.

At the end of the relettered Paragraph (*e*) add the following sentence:

> The thermometer shall be approximately at room temperature when placed in the flask.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 481.

[2] *Ibid.*, p. 500.

In the relettered Paragraph (*g*) change the third sentence to read as follows by the addition of the italicized words and the omission of the word in brackets:

> The top of the graduate shall be covered closely during the distillation with a piece of blotting paper, or its equivalent, [and] *so* cut *as* to fit the condenser tube tightly.

Section 10.—Change the first sentence of this section to read as follows by the addition of the italicized word:

> When everything is in readiness, heat shall be applied *immediately* at a uniform rate, so regulated that the first drop of the condensate falls from the condenser in not less than two nor more than five minutes.

Change the third paragraph of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> The heating shall be continued until the mercury reaches a maximum and starts to fall consistently *after the bottom of the flask has become dry*. The highest temperature observed on the distillation thermometer shall be recorded as the *maximum temperature or* end point. [Usually this point will be reached after the bottom of the flask has become dry. If the bottom of the flask is not dry, the operator should note this on the report.]

Section 13.—Omit this section which reads as follows:

> 13. The form shown in Fig. 3 is suggested for the recording of results of tests of natural gas gasoline.

Figure 3.—Omit this figure which shows the form for recording test results.

Tentative Method of Test for Vapor Pressure of Natural Gasoline (Reid Method) (D 323 – 30 T).[1]—Subcommittee XXII on Natural Gasoline (G. G. Oberfell, chairman) has recommended a number of revisions in this method in order to clarify the procedure and to permit of reasonable variation in the methods of constructing the specified apparatus. The method, as revised, is appended hereto[2] and it is recommended that the revised method be approved and continued as tentative.

Tentative Definitions of Terms Relating to Petroleum (D 288 – 28 T)[3]—The following change in the definition of the term "fuel oil" is proposed by Subcommittee XX on Nomenclature (J. B. Rather, chairman). It is recommended that with this revision the definitions be continued as tentative:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1139 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 396.

[2] See p. 808.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 933 (1928); also 1930 Book of A.S.T.M. Tentative Standards, p. 402.

Fuel Oil.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> Fuel oil.—Any liquid or liquefiable petroleum product [used] ***burned*** for the generation of heat in [a] ***an industrial or household*** furnace or firebox, [the controlling factors being cost and adaptability] ***or for the generation of power in a diesel engine, exclusive of oils with a flash point below 100° F., Tag closed tester, and oils burned in cotton or wool-wick burners.*** Fuel oils in common use fall into one of four classes: (1), residual fuel oils, which are topped crude petroleums or viscous residuums obtained in refinery operations; (2) distillate fuel oils, which are distillates derived directly or indirectly from crude petroleum; (3) crude petroleums and weathered crude petroleums of relatively low commercial value; (4) blended fuels, which are mixtures of two or more of the three ***preceding*** classes.

There are five tentative methods of test developed by the committee that have remained in tentative form without modification for three years or longer. Tentative Method of Test for Color of Lubricating Oils by Means of Union Colorimeter (D 155 – 23 T); Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (D 156 – 23 T); and Tentative Method of Test for Color of Petrolatum by Means of Union Colorimeter (D 218 – 25 T) have not been advanced to standard because of a need for requirements for the color standards. The development of these requirements is now under way,

Consideration is now being given to a revision of Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 – 27 T) to broaden its usefulness in the case of dark-colored oils. Work is being carried out with hard greases to extend the application of Tentative Method of Test for Penetration of Greases and Petrolatum (D 217 – 27 T).

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF STANDARDS			
Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30)	55	1	0
Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 30)	55	0	1
Test for Cloud and Pour Points of Petroleum Products (D 97 – 30)	51	2	3
Test for Distillation of Natural Gas Gasoline (D 216 – 30)	50	0	6
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Method of Test for Vapor Pressure of Natural Gasoline (Reid Method) (D 323 – 30 T)	52	0	4
Tentative Definitions of Terms Relating to Petroleum (D 288 – 28 T)	54	1	1

This report has been submitted to letter ballot of the committee, which consists of 81 members; 56 members returned their ballots, of whom 54 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

F. A. HULL,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

The proposed tentative revisions of the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants and Test for Distillation of Natural Gas Gasoline were accepted for publication as tentative.

The proposed revisions of the Standard Methods of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products and Test for Cloud and Pour Points or Petroleum Products were approved as editorial changes.

The proposed revisions of the Tentative Method of Test for Determination of Vapor Pressure of Natural Gasoline (Reid Method) and of the tentative definition of the term "fuel oil" appearing in the Tentative Definitions of Terms Relating to Petroleum were accepted. The method and definitions in their revised form appear on pages 808 and 815.

REPORT OF SUBCOMMITTEE XVI ON CLOUD AND POUR TEST

Several members of Committee D-2 have had difficulty in obtaining check results in the determination of the pour point on certain oils by the special procedure for black oils and cylinder stocks described in Section 12 of the Standard Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 30).[1] In view of this fact the subcommittee felt it desirable to make a series of tests on oils which were reported to give unsatisfactory check results by this procedure and to determine what change, if any, should be made in this method.

The history of the test procedure may be summarized as follows: In 1924, it was demonstrated that the pour points of certain types of oils, notably cylinder stocks and black oils, were affected by the temperature to which the oil was heated prior to testing.[2] It was further shown in the case of eight oils from widely varying crude-petroleum sources, that heating to 115° F., gave, in the case of these oils, a higher pour point than that obtained by heating to any other temperature. Accordingly, the present Standard Method D 97 – 30, was adopted and into this method was incorporated a special procedure for black oils and cylinder stocks which contained, as an essential detail, the heating of the oil to 115° F. prior to testing in order to establish the highest pour point, it being felt that a pour point obtained in this manner would represent the highest pour point which the oil would be likely to acquire under storage conditions.

During the past year, fifteen oils were submitted by committee members because of their anomalous behavior when tested according to the present procedure. The pour points of these were determined in the chairman's laboratory by the present A.S.T.M. method and also by a new procedure which it was felt would give the highest pour point obtainable under any conditions. This new procedure involved heating the oil to 220° F., and then cooling to 0° F., and reheating to a series of temperatures and testing in the usual manner. The pour points obtained by this new procedure varied, as would be expected, with the temperature to which the oil was heated. The highest pour point obtained by this new procedure is compared in Table I with the pour point obtained using the procedure of Method D 97.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 481.

[2] J. B. Rather and H. M. Anderson, "A Proposed Modification of the A.S.T.M. Pour Test Applicable to Those Oils Which Give Erratic Results by the Present Method," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 553 (1924).

The highest pour points obtained by the new procedure, given in Table I, were obtained by heating to a predetermined temperature, somewhere between 70° F. and 150° F., although the majority were obtained by heating to temperatures in the neighborhood of 115° F. At this temperature the pour point is usually little affected by slight variations in the temperature to which the oil is heated.

TABLE I.—POUR POINTS OF VARIOUS OILS OBTAINED BY TWO DIFFERENT PROCEDURES.

OIL SAMPLE	HIGH POUR POINT, A.S.T.M. METHOD D 97 – 30, DEG. FAHR.	HIGHEST, POUR POINT, NEW PROCEDURE, DEG. FAHR.	DIFFERENCE, DEG. FAHR.
1. Steam-refined stock, Bradford crude, The Pennzoil Co.	55	60	5
2. Cabin Creek cylinder stock, The Pure Oil Co.	65	90	25
3. Untreated steam-refined stock, Pierce Petroleum Corp.	65	90	25
4. Steam-refined stock, Mid-Continent Petroleum Corp.	70	80	10
5. 600 steam-refined cylinder stock, third-sand Pennsylvania crude oil, The Pennzoil Co.	80	85	5
6. Ranger A cylinder stock, Standard Oil Co. of New York	100	100	0
7. Continental cylinder stock, Standard Oil Co. of New York	105	105	0
8. Dewaxed bright stock, Magnolia Petroleum Co.	5	10	5
9. Pennsylvania A cylinder stock, Standard Oil Co. of New York	30	35	5
10. Santa Fe Springs residuum, General Petroleum Corp.	90	90	0
11. Mixture of 80-per-cent Baku fuel oil and 20-per-cent Grozny mazut	65	60	5
12. Black oil stock, The Texas Co.	85	95	10
13. Summer black oil, The Texas Co.	60	65	5
14. Western cylinder stock, The Texas Co.	85	95	10
15. Cylinder stock, Wadhams Oil Co.	70	[a]	..

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[a] In the case of this particular oil the pour point obtained by the present A.S.T.M. procedure was higher than that obtained by the new procedure.

As will be noted from Table I, all except three of these oils have pour points which check within 10° F., and all except six check within 5° F., of the pour point obtained by the new procedure.

This work indicates that the present A.S.T.M. Method D 97 – 30 will give a pour point for the great majority of oils which is as high as any pour point which the oil is likely to acquire under storage conditions. Some oils, notably Pennsylvania cylinder stocks, sometimes show anomalous behavior, and if an oil is recognized as being of this character its highest pour point can be determined by heating to a series of temperatures and selecting the highest pour point obtained.

The subcommittee recommends that the Standard Method of Test for Cloud and Pour Points of Petroleum Products (D 97 - 30) remain unchanged except for the minor editorial changes incorporated in the body of the report of Committee D-2.

Respectfully submitted on behalf of the subcommittee,

J. B. RATHER,
Chairman.

REPORT OF TECHNICAL COMMITTEE A ON GASOLINE

The ultimate objective of Technical Committee A is the formulation of specifications for gasoline, primarily gasoline for use as motor fuel. Since further correlation between test data and service performance is necessary, such correlation has constituted the chief activity of the committee during the past year.

The Section on Gum (T. H. Rogers, chairman), has demonstrated by road tests on various cars that a gasoline containing, at time of use, between 15 and 25 mg. of preformed gum per 100 cc., is unsatisfactory because most cars show gum deposits on the intake manifold, and in some cases on the intake valves, long before being driven the 10,000 miles tentatively established as a criterion. Tests are now in progress using a gasoline containing about one-half this amount of dissolved or preformed gum. Methods of determining preformed gum are also being studied comparatively. The measurement and effect of potential gum, that is, gum which forms during storage of gasoline, will receive consideration as soon as work on preformed gum is complete.

The Section on Vapor Lock (G. G. Brown, chairman) has agreed without dissenting vote that the quality of gasoline which indicates its tendency to cause vapor lock is its vapor pressure; that vapor pressure of gasoline must be limited by specification to give reasonable protection to the user so far as fuel is concerned; and that the Tentative Method of Test for Vapor Pressure of Natural Gasoline (Reid Method) (D 323 – 30 T)[1] is the most suitable now available. The use of a smaller Reid bomb is under consideration. Elaborate work has been done by various agencies on measurement of fuel-system temperatures under driving and idling conditions with various makes and models of car. It is obvious from this work that vapor lock in general has been due to faulty design of fuel system rather than fuel quality. Automotive interests are now fully cognizant of this fact and are correcting the design in new models. This will permit the use of somewhat better gasoline.

The Section on Corrosion (J. B. Terry, chairman) is inactive pending the provision of funds necessary to carry on an investigation of the maximum permissible sulfur limits under various climatic and seasonal conditions. In cooperation with the Cooperative Motor Fuel Research Committee of the American Petroleum Institute, the

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[1] See p. 808.—Ed.

Society of Automotive Engineers, the National Automobile Chamber of Commerce, and the U. S. Bureau of Standards, a research program and estimate of cost and duration is in preparation.

Other important qualities, such as knocking, starting, acceleration, etc., are not being studied because the Cooperative Motor Fuel Research Committee is ably procuring information which Technical Committee A will utilize eventually in preparing specification limits.

While no specifications have yet been prepared, the committee has commented informally, but in a helpful manner, on municipal specifications submitted to the Society and has also devoted considerable time to the consideration of the form and substance of federal specifications for gasoline. The activity of the members of this committee and the intelligent cooperation of petroleum, automotive, consuming, and general interests is a source of real gratification to the officers.

Respectfully submitted on behalf of the technical committee,

H. L. HORNING,
Chairman.

T. G. DELBRIDGE,
Secretary.

REPORT OF TECHNICAL COMMITTEE B ON MOTOR OILS

Technical Committee B on Motor Oils was organized in 1929 under the direction of Committee D-2. The first meeting was held December 3, 1929, and meetings have been held at irregular intervals since that date.

According to the By-laws of Committee D-2, "The principal function of technical committees shall be to study the relation between test data and service performance of materials and to prepare and recommend material specifications to Committee D-2."

The first problem of this technical committee was to obtain the cooperation of representatives from the different industries so that work done by the committee would be truly representative, and that the different interests, both producing and consuming, would be properly considered. A large amount of time was spent selecting the members and trying to develop a method of attack. It was developed quite early in the work that it is impossible to list properties of motor oils, such as gravity, viscosity, flash point and fire point with maximum and minimum limits, and obtain in this manner suitable specifications. The properties which are desired in motor oils depend upon the type of engine and the conditions of service. An oil within certain limits as to gravity, viscosity, flash point and fire point might be very satisfactory for a certain type of service and very unsatisfactory for another type of service. In addition, oils which differ widely in some of their properties might be equally satisfactory for a particular use.

The committee then undertook the problem of trying to show the relation between the properties of the lubricants and performance in service, with the idea of using these data when obtained as a basis for specifications. The committee will develop the possibility of basing specifications on the performance required of the lubricants under different conditions of service as differentiated from specifications based on a tabulation of maximum and minimum properties of lubricants.

The membership of Technical Committee B has been divided into five sections with chairmen as follows:

Section on Carbon, W. A. Gruse, Mellon Institute of Industrail Research

Section on Oil Consumption, W. H. Graves, Packard Motor Car Co.

Section on Pour Point, J. L. McCloud, Ford Motor Co.

Section on Service Change, A. E. Flowers, The De Laval Separator Co.

Section on Viscosity, E. W. Upham, Chrysler Corporation

Reports covering the respective fields are being prepared by these sections for distribution to the members of Technical Committee B and of Committee D-2 for discussion and criticism, with the hope of reaching agreement upon a foundation from which the future work of the technical committee may be developed.

Respectfully submitted on behalf of the technical committee,

H. C. MOUGEY,
Chairman.

J. G. DETWILER,
Secretary.

REPORT OF COMMITTEE D-4
ON
ROAD AND PAVING MATERIALS

During the past year, Committee D-4 on Road and Paving Materials has undergone a complete reorganization which, while temporarily retarding work, will expedite it in the future. Under the old organization, the committee was divided into two large subcommittees, one on bituminous materials and the other on non-bituminous materials. Each of these subcommittees was subdivided into sections which reported to the main committee only through their parent subcommittee.

Under the new organization the two large subcommittees have been eliminated and the main committee has been divided into a large number of subcommittees in which no sharp distinction is necessarily made between the two main classes of materials. Some of these subcommittees deal only with methods of test and some only with specifications but all report directly to the main committee. Three vice-chairmen have been appointed, whose duty it is to maintain close contact with certain groups of subcommittees and assist in the correlation of their work.

Because of this reorganization many of the subcommittees have only recently started to function. There are a number of tentative standards under the jurisdiction of the committee which have had a tentative status for three years or longer, and due to the reorganization of the committee it has not been possible to take action on these tentative standards, and the committee accordingly recommends that they be continued as tentative another year.

The following projects are now well under way and should result in recommendations being made to the Society at the next annual meeting:

Group B. Subcommittees on Methods of Tests:

B-1 on Asphalt Content
B-2 on Physical Tests for Compressed Bituminous Mixtures
B-3 on Distillation of Bituminous Materials
B-4 on Ductility Tests of Bituminous Materials
B-5 on Softening Point Tests of Bituminous Materials
B-6 on Methods of Extracting Bituminous Aggregates

B-7 on Viscosity and Float Tests for Bituminous Materials
B-8 on Coefficient of Expansion of Bituminous Materials
B-9 on Mechanical Analysis of Mineral Aggregates
B-10 on Determination of Percentage of Soft Fragments in Mineral Aggregates
B-11 on Determination of Cleanliness of Mineral Aggregates
B-12 on Abrasion Tests of Coarse and Fine Aggregates
B-13 on Crushing Strength Tests of Aggregates
B-14 on Methods of Determining Specific Gravity of Fine and Coarse Aggregates
B-15 on Methods of Sampling Mineral Aggregates
B-16 on Determination of Setting Qualities of Bituminous Materials

Group C. Subcommittees on Specifications for Materials and Material Combinations:

C-1 on Asphalt Cements
C-2 on Tar Products
C-3 on Road Oils
C-4 on Emulsified Asphalts
C-5 on Portland-Cement Concrete for Pavements and Bases
C-6 on Brick and Block for Pavements
C-7 on Materials for Earth and Oiled-Earth Roads
C-8 on Materials for Waterbound and Traffic-bound Roads
C-9 on Materials for Bituminous Surfaces and Bases

Group D. Subcommittees on Miscellaneous Materials:

D-1 on Calcium Chloride for Dust Palliative, Curing and Ice Melting
D-2 on Highway Traffic Markers
D-3 on Expansion-Joint Materials and Fillers

During the past two years, one of the sections, now Subcommittee C-3 on Specifications for Road Oils, has carried on exhaustive investigations leading to the formulation of proposed specifications for road oils, namely, specifications for slow-curing road oils, for medium-curing road oils, for hot-application road oils and for cut-back asphalts. While Committee D-4 is not at this time prepared to recommend their publication as tentative standards it nevertheless believes that the work accomplished is of sufficient value to warrant publication of the report of the subcommittee, which is accordingly appended hereto.

Subcommittee D-1 on Specifications and Methods of Test for Calcium Chloride, for Dust Palliative, Curing and Ice Melting has prepared proposed Methods of Chemical Analysis of Calcium Chloride which were received too late for presentation to the Society at the annual meeting. After these proposed methods, appended hereto[1] for information, have been approved by letter ballot of Committee D-4 they will be submitted to Committee E-10 on Standards at a meeting to be held after the annual meeting with the recommendation that they be approved as a tentative standard.

RECOMMENDATIONS AFFECTING STANDARDS

Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 30).[2]—It has been called to the attention of the committee that under some test conditions the bulb of the high-distillation thermometer described in this method may be heated to a point that will impair the accuracy of the instrument and throw such accuracy beyond the tolerance permitted by the specifications. The committee accordingly recommends the addition to this method of a note of caution regarding the high-distillation thermometer. The note, which reads as follows, originated in Committee D-15 on Thermometers and it is recommended that it be added at the end of Section 6:

> NOTE.—Under certain test conditions the bulb of the thermometer may be 50° F. (28° C.) above the temperature indicated by the thermometer, and at an indicated temperature of 700° F. (371° C.) the temperature of the bulb is approaching a critical range in the glass. It is therefore not desirable to use this thermometer under such conditions at indicated temperatures above 700° F. (371° C.) without checking the ice point.

As this note merely describes a precautionary measure which may be considered as an editorial change, it has not been referred to letter ballot of Committee D-4, but unanimous approval was given by the Committee at a meeting on June 22.

Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 - 18).[3]—In the 1929 report,[4] Committee D-4 signified its approval of certain definitions for bituminous materials recommended by a joint conference committee composed of representatives of Committee D-2 on Petroleum Products and Lubricants, Committee D-8 on Bituminous Waterproofing and Roofing Materials and Committee D-4. Since that time the joint conference committee has made a number of minor changes in the definitions to meet certain suggestions and criticisms that have been received. These revisions have also been approved by Committee D-4 which now recommends that the following definitions be approved for publication as tentative revisions of the existing standard definitions.

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[1] See p. 490.—ED.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 642.

[3] *Ibid.*, p. 673.

[4] See *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 382 (1929).

Bitumens.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Bitumens.—Mixtures of [native or pyrogenous] hydrocarbons *of natural or pyrogenous origin, or combinations of both* [and] *frequently accompanied by* their non-metallic derivatives, which may be [gases] *gaseous,* [liquids] *liquid,* [viscous liquids] *semisolid,* or [solids] *solid,* and which are *completely* soluble in carbon disulfide.

Asphalts.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Asphalts.—*Black to dark brown* solid or semi-solid [native bitumens, solid or semi-solid bitumens obtained by refining petroleum, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt upon the application of heat] *cementitious materials which gradually liquefy when heated, in which the predominating constituents are bitumens all of which occur in the solid or semi-solid form in nature or are obtained by refining petroleum, or which are combinations of the bitumens mentioned with each other or with petroleum or derivatives thereof* [and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds].

Flux.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

[Flux] *Fluxes.*—[Bitumens] *Bituminous materials,* generally liquid, *in which the predominating constituent is bitumen,* used in combination with [harder bitumens] *asphalts* for the purpose of softening the latter.

Tars.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Tars.—[Bitumens] *Black to dark-brown bituminous condensates* which yield [pitches upon fractional distillation] *substantial quantities of pitch when partially evaporated or fractionally distilled,* and which are produced [as distillates] by [the] destructive distillation of [bitumens, pyrobitumens or] organic [materials] *material, such as coal, oil, lignite, peat and wood.*

Pitches.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Pitches.—*Black or dark-brown* solid *cementitious* residues *which gradually liquefy when heated and which are* produced [in] *by* the *partial* evaporation or *fractional* distillation of [bitumens, the term being usually applied to residues obtained from] tars.

The results of the letter ballot of the committee upon the recommendations made in this report appear in the following table:

Items	Affirm-ative	Neg-ative	Not Voting
PROPOSED REVISION OF STANDARD			
Definitions of Terms Relating to Materials for Roads and Pavements (D 8 - 18):			
Revision of Term Bitumens	52	0	10
Revision of Term Asphalts	52	0	10
Revision of Term Flux	51	1	10
Revision of Term Tars	49	3	10
Revision of Term Pitches	51	1	10

This report has been submitted to letter ballot of the committee, which consists of 78 members; 62 members returned their ballots, of whom 57 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

P. J. FREEMAN,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the definitions of the terms "bitumens," "asphalts," "flux," "tars," and "pitches," appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements, were accepted for publication as tentative and appear on page 1069.

The addition of the Note to the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment was approved as an editorial change.

REPORT OF SUBCOMMITTEE C-3 ON SPECIFICATIONS FOR ROAD OILS

The Subcommittee on Specifications for Road Oils has prepared a group of proposed specifications for road oils, namely, specifications for slow curing road oils; for medium curing road oils; for hot application road oils; and for cut-back asphalts. These specifications are appended hereto for information before being recommended to the Society for publication as tentative standards.

The task of the subcommittee has been a difficult one. There exists a great divergence of opinion and practice in connection with the specification of road oils. Many different grades are required and the ways in which they are specified differ widely. Some consumers define the constituent materials as well as the finished product, while others specify the latter only. So many different tests and test conditions are used that accurate comparison of existing specifications is virtually impossible. Although there are some examples of local standardization, the situation, generally, is most confused.

As a step in the development of the subcommittee's work, a preliminary set of specifications was sent to each state highway department and to a number of producers, with a request for comments, criticisms and comparison with their own requirements. Replies were received from more than thirty states. It was evident that our specifications had received careful consideration, and that the desirability of standard requirements was realized.

Although several states were favorably disposed toward the subcommittee's specifications, others preferred those which they had developed. It is, of course, recognized that local conditions of use, crude materials, and methods of manufacture vary throughout the country and that these factors have contributed to the evolution of the many different specifications. A study of the replies emphasized the hopelessness of attempting to write specifications which would include all of those in current use.

Therefore, the subcommittee has prepared a group of specifications which it believes adequately covers the various types and uses of road oils, as well as can be done under present conditions. Four types of products are defined, each of which is offered in several grades, which differ chiefly in consistency. The entire group is composed of fourteen grades. It has been claimed that this is an unnecessarily large number, and the subcommittee believes that some might be eliminated. For the present, however, it is believed that all should be included in order to conform, as closely as possible, to present practice.

The subcommittee believes that *all* road oils may, and should be specified by a few standard tests common to all. The following are suggested:

Specific Viscosity at 25° C., 50° C., or 100° C. (77° F., 122° F., or 212° F.);
Flash Point;
Total Bitumen;
Distillation with initial boiling point and cuts at three intermediate temperatures;
Tests on Residue from Distillation:
  Consistency by Float or Penetration Test; and
  Ductility.

It is believed that the adoption of standard tests would facilitate the understanding of road oils and very greatly simplify the task of formulating standard specifications.

Respectfully submitted on behalf of the subcommittee,

W. J. EMMONS,
Chairman.

APPENDIX I

PROPOSED SPECIFICATIONS FOR SLOW CURING ROAD OILS

1. *Scope.*—(*a*) These specifications cover four grades of slow curing road oils, Grades A, B, C, and D, composed of asphaltic residues, blended or unblended with relatively non-volatile distillates. Ability to penetrate into fine grained surfaces is an essential characteristic of these products.

(*b*) The purposes for which these grades are frequently used, dependent upon their consistencies, are as follows:

Grade A..	Dust palliative for earth or higher types (excluding hard surface pavements); Does not require heating for proper application; Does not require mineral cover.
Grade B..	Dust palliative for earth, sand-clay, shell, and gravel surfaces; Light surface treatment on earth, sand-clay shell, and gravel surfaces; Does not require heating for proper application; Requires light application of clean mineral cover when used for surface treatment.
Grade C..	Surface treatment on earth, sand-clay, shell, and gravel surfaces; Mixed-in-place types on which maintenance is to be accomplished by blading; Ordinarily does not require heating for proper application; Requires clean mineral cover when used for surface treatment.
Grade D..	Heavy surface treatment on earth, sand-clay, shell, and gravel surfaces; Mixed-in-place types on which maintenance is to be accomplished by blading; Generally requires heating for proper application; Requires mineral cover for surface treatment.

2. *Properties.*—The oil shall conform to the requirements specified by the purchaser, within the following limits:

	Grade A		Grade B		Grade C		Grade D	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
(*a*) Specific viscosity, Engler:								
50 cc., 25° C. (77° F.).....	...	20	20	50	...	...	...	...
50 cc., 50° C. (122° F.)....	...	...	...	...	10	40	35	65
(*b*) Residue of 100 penetration, per cent...........	25	40	40	55	55	65	65	75
(*c*) Ductility at 25° C. (77° F.) of residue of 100 penetration, cm.............	...	...	50	...	50	...	50	...

	GRADE A		GRADE B		GRADE C		GRADE D	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
(*d*) Loss on heating, 163° C. (325° F.), 50 g., 5 hr., per cent	...	20	...	10	...	8	...	8
(*e*) Residue from loss on heating test	Liquid							
(*f*) Flash point, open cup, deg. Cent	65	...	90	...	90	...	90	...
(*g*) Total bitumen, soluble in carbon disulfide, per cent	99	...	99	...	99	...	99	...

3. *Methods of Testing.*—The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as noted in Paragraph (*a*):

(*a*) *Specific Viscosity:*[1] Method contained in *Bulletin No. 1216*, U. S. Department of Agriculture, the instrument being standardized by the U. S. Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F);

(*b*) *Residue of 100 Penetration:* Tentative Method of Test for Residue of Specified Penetration (A.S.T.M. Designation: D 243 – 28 T);[2]

(*c*) *Ductility of Residue:* Tentative Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113 – 26 T);[3]

(*d*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6);[4]

(*e*) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92);[5]

(*f*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 948 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 527.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 886 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 524.

[4] 1930 Book of A.S.T.M. Standards, Part II, p. 638.

[5] *Ibid.*, p. 517.

[6] *Ibid.*, p. 633.

APPENDIX II

PROPOSED SPECIFICATIONS FOR MEDIUM CURING ROAD OILS

1. *Scope.*—(*a*) These specifications cover three grades of medium curing road oils, Grades A, B, and C, composed of asphaltic residues, blended or unblended with distillates which gradually volatilize upon exposure, leaving a base of plastic consistency.

NOTE.—The use of these materials, in combination with mineral cover, may be expected to result in the formation of a thin malleable surface mat. Some penetration into the road surface may be anticipated with oils conforming to Grades A and B, unless prevented by unusual compactness or excessive dustiness.

(*b*) The purposes for which these grades are frequently used, dependent upon their consistencies, are as follows:

Grade A..	Light surface treatment on sand-clay, shell, gravel, and water-bound macadam surfaces; Does not require heating for proper application; Should preferably be covered with clean mineral material of not over ¼-in. maximum size.
Grade B..	Surface treatment on sand-clay, shell, gravel, and water-bound macadam surfaces; Ordinarily does not require heating for proper application; Requires clean mineral cover, nor exceeding ½-in. in maximum size.
Grade C..	Surface treatment on gravel, and water-bound macadam surfaces; Retreatment on sand-clay, shell, gravel, and water-bound macadam surfaces; Generally requires heating for proper application; Requires clean mineral cover.

2. *Properties.*—The oil shall conform to the requirements specified by the purchaser, within the following limits:

	GRADE A		GRADE B		GRADE C	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
(*a*) Specific viscosity, Engler:						
50 cc., 25° C. (77° F.)	20	50	...	...	...	...
50 cc., 50° C. (122° F.)	...	...	15	30	35	70
(*b*) Residue of 100 penetration, per cent	40	55	55	65	65	75
(*c*) Ductility at 25° C. (77° F.) of residue of 100 penetration, cm	50	...	50	...	50	...
(*d*) Loss on heating, 163° C. (325° F.), 50 g., 5 hr., per cent	15	30	10	20	10	20
(*e*) Float test at 32° C. (89.6° F.) of residue from loss on heating test, seconds	15	100	20	150	20	200
(*f*) Flash point, open cup, deg. C.	50	...	50	...	50	...
(*g*) Total bitumen, soluble in carbon disulfide, per cent	99	...	99	...	99	...

4. *Methods of Testing.*—The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as noted in Paragraph (*a*):

(*a*) *Specific Viscosity:*[1] Method contained in *Bulletin No. 1216*, U. S. Department of Agriculture, the instrument being standardized by the U. S. Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.);

(*b*) *Residue of 100 Penetration:* Tentative Method of Test for Residue of Specified Penetration (A.S.T.M. Designation: D 243 - 28 T);[2]

(*c*) *Ductility of Residue:* Tentative Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113 - 26 T);[3]

(*d*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6);[4]

(*e*) *Float on Residue:* Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139);[5]

(*f*) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92);[6]

(*g*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[7]

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[1] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 948 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 527.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 886 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 524.

[4] 1930 Book of A.S.T.M. Standards, Part II, p. 638.

[5] *Ibid.*, p. 660.

[6] *Ibid.*, p. 517.

[7] *Ibid.*, p. 633.

APPENDIX III

PROPOSED SPECIFICATIONS FOR HOT APPLICATION ROAD OILS

1. *Scope.*—(*a*) These specifications cover three grades of hot application road oils, Grades A, B, and C, composed of straight run or blended asphaltic residues.

(*b*) The purposes for which these grades are frequently used are as follows:

Surface treatment on primed sand-clay, gravel, or water-bound macadam surfaces;

Retreatment of existing bituminous surfaces and bituminous pavements.

Note.—Treatments defined in Paragraph (*b*) require the application of clean mineral cover.

2. *Properties.*—The oil shall conform to the requirements specified by the purchaser, within the following limits:

	Grade A		Grade B		Grade C	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
(*a*) Specific viscosity, Engler, 50 cc. at 100° C. (212° F.)	...	60	...	...	...	...
(*b*) Float test at 50° C. (122° F.), seconds	30	...	100	175	225	...
(*c*) Residue of 100 penetration, per cent	75	90	85	95	95	...
(*d*) Ductility at 25° C. (77° F.) of residue of 100 penetration, cm	50	...	50	...	50	...
(*e*) Loss on heating, 163° C. (325° F.), 50 g., 5 hr., per cent	...	10	...	7	...	3
(*f*) Float test at 50° C. (122° F.) of residue from loss on heating test, seconds	40	...	125	...	...	..
(*g*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue from loss on heating test	...	...	...	...	125	...
(*h*) Flash point (open cup), deg. Cent	100	...	163	...	220	...
(*i*) Total bitumen, soluble in carbon disulfide, per cent	99	...	99	...	99	...

3. *Methods of Testing.*—The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as noted in Paragraph (*a*):

(*a*) *Specific Viscosity:*[1] Method contained in *Bulletin No. 1216*, U. S. Department of Agriculture, the instrument being standardized by the U. S. Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.);

(*b*) *Float Test:* Standard Method of Float Test for Bituminous Materials (A.S.T.M. Designation: D 139);[2]

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[1] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 660.

(*c*) ***Residue of 100 Penetration:*** Tentative Method of Test for Residue of Specified Penetration (A.S.T.M. Designation: D 243 – 28 T);[1]

(*d*) ***Ductility of Residue:*** Tentative Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113 – 26 T);[2]

(*e*) ***Loss on Heating:*** Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (A.S.T.M. Designation: D 6);[3]

(*f*) ***Penetration:*** Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5);[4]

(*g*) ***Flash Point:*** Standard Method of Test for Flash and Fire Points by Means of Open Cup (A.S.T.M. Designation: D 92);[5]

(*h*) ***Total Bitumen:*** Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[6]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 948 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 527.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 886 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 524.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 638.

[4] *Ibid.*, p. 647.

[5] *Ibid.*, p. 517.

[6] *Ibid.*, p. 633.

APPENDIX IV

PROPOSED SPECIFICATIONS FOR CUT-BACK ASPHALTS

1. *Scope.*—(*a*) These specifications cover four grades of cut-back asphalts, Grades A, B, C, and D, composed of asphalt cement cut-back with a solvent of such volatility as will permit the asphalt cement to revert to its original consistency:

(*b*) The purposes for which these grades are frequently used are as follows:

Initial surface treatment of well-bonded gravel or water-bound macadam surfaces;

Retreatment of existing bituminous surfaces and bituminous pavements;

Mixed-in-place surface types, particularly those composed of aggregates coarser than ¼-in. in maximum size;

Coating of aggregate in the preparation of cold patch mixtures.

NOTE.—A cover of clean mineral material is required when these materials are used for surface treatment or seal coating.

2. *Properties.*—The cut-back asphalt shall conform to the requirements specified by the purchaser, within the following limits:

	GRADE A		GRADE B		GRADE C		GRADE D	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
(*a*) Specific Viscosity, Engler:								
50 cc., 25° C. (77° F.).....	40	80	...	...	...	...	...	...
50 cc., 50° C. (122° F.)....	...	...	15	30	50	100	150	200
(*b*) Distillation:								
Total volume to 225° C. (437° F.), per cent......	10	...	10	...	10	...	5	...
Total volume to 315.5° C. (600° F.), per cent......	30	...	25	...	20	...	15	...
Total volume to 360° C. (680° F.), per cent......	...	43	...	38	...	35	...	30
TESTS ON RESIDUE FROM DISTILLATION:								
(*c*) Penetration at 25° C. (77° F.), 100 g., 5 sec.....	60	125	60	125	60	125	60	125
(*d*) Ductility at 25° C. (77° F.), cm.................	60	...	60	...	60	...	60	...
(*e*) Total bitumen, soluble in carbon disulfide, per cent	99	...	99	...	99	...	99	...

3. *Methods of Testing.*—The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as noted in Paragraphs (*a*) and (*b*):

(*a*) *Specific Viscosity:*[1] Method contained in *Bulletin No. 1216*, U. S. Department of Agriculture, the instrument being standardized by the U. S. Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.);

(*b*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (A.S.T.M. Designation: D 20),[2] with the following exceptions:

> Distillation to be made on 200-cc. sample; condenser to be water cooled; thermometer bulb to be $\frac{1}{2}$-in. from bottom of flask; first drop to come over in 10 to 15 minutes after application of heat; residue to be poured immediately after maximum temperature is attained, to avoid condensation of vapor in residue;

(*c*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (A.S.T.M. Designation: D 5);[3]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (A.S.T.M. Designation: D 113 - 26 T);[4]

(*e*) *Total Bitumen:* Standard Method of Test for the Determination of Bitumen (A.S.T.M. Designation: D 4).[5]

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[1] **The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.**

[2] **1930 Book of A.S.T.M. Standards, Part II, p. 642.**

[3] ***Ibid.*, p. 647.**

[4] ***Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 886 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 524.**

[5] **1930 Book of A.S.T.M. Standards, Part II, p. 633.**

APPENDIX V

PROPOSED METHODS OF CHEMICAL ANALYSIS OF CALCIUM CHLORIDE[1]

DETERMINATION OF TOTAL CALCIUM

1. Weigh accurately a sample of approximately 5 g. (see Note 1) and dissolve in water. Add sufficient HCl to clear, and then make up to a volume of 500 cc. Pipette a 25.00 ml. aliquot and add enough dilute NH_4OH to make slightly alkaline. Methyl orange or red may be used as indicator. Add 20 ml. of cold, saturated NH_4Cl solution and dilute to from 100 to 125 ml. Heat to boiling and while stirring to precipitate the calcium add 20 ml. of cold saturated $(NH_4)_2C_2O_4$. Let stand one minute and if the precipitate does not show a tendency to settle well, bring back to boiling and continue the stirring. Let settle 20 minutes and filter through No. 42, 11-cm. Whatman filters or paper of an equivalent grade. Wash free from oxalate and chloride with hot water. Wash the precipitate back into the original beaker and dilute to about 100 ml. Dissolve the precipitate with 10 to 15 ml. of 0.25 *N* H_2SO_4, heat to about 80° C. and titrate to a pink color with 0.1 *N* KMnO4. Add the paper and finish the titration to a faint pink with the standard KMnO4.

Percentage of $CaCl_2$ = Wt. of sample in grams + (cubic centimeters of 0.1 *N* KMn04 × 0.00555 × 100)

The calculated percentage of $CaCl_2$ shall be corrected for $Ca(OH)_2$ and $CaCO_3$.

DETERMINATION OF TOTAL ALKALINITY AND MAGNESIUM COMPOUNDS

2. Weigh accurately a 10.00-g. sample (see Note 1), place in a 400-ml. beaker and dissolve in 25 ml. of water. Add a drop of phenolphthalein indicator and titrate with 0.1 *N* HCl till the brilliant pink color fades or becomes a dull, slowly-returning color when tested by adding another drop or two of indicator. Then add enough of the 0.1 *N* HCl in excess to give a permanent red color after the addition of a drop of methyl orange indicator. Titrate back to the neutral point with 0.1 *N* NaOH and adjust to a faint pink color with 0.1 *N* HCl. Use these solutions for the subsequent determination of magnesium compounds.

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[1] Criticisms of these Proposed Methods are solicited and should be directed to Mr. Prevost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

The net volume of acid used is sometimes calculated as calcium hydroxide for convenience, as follows:

Percentage of $Ca(OH)_2$ = milliliters of 0.1 *N* HCl × 0.0037 × 10

To the neutral solutions add 9 ml. of normal NaOH solution which will precipitate $Mg(OH)_2$ along with some $Ca(OH)_2$. Filter the precipitate and transfer as much as possible to the filter. Now dissolve the precipitate from the paper to the original beaker with about 10 ml. of HCl(1:1). Add 30 ml. of cold, saturated NH_4Cl solution. With a volume of about 150 ml., heat to boiling and add from 50 to 60 ml. (or an excess) of cold saturated $(NH_4)_2C_2O_4$ solution. Heat just to boiling while stirring, and slowly make alkaline with dilute NH_4OH. Let stand 10 to 15 minutes and filter through a retentive qualitative paper such as Whatman's No. 2 or 3. Save this filtrate. Return the precipitate to the original beaker, dissolve in HCl (1:1) as before, add 15 ml. of cold saturated NH_4Cl solution and 10 ml. of the $(NH_4)_2C_2O_4$ solution, heat to boiling and slowly make alkaline with dilute NH_4OH. When the precipitate is well formed and settles readily, filter as before, and combine the two perfectly clear filtrates. Concentrate to about a 250-ml. volume. If much magnesium is present, the oxalate may precipitate. Add HCl to dissolve it. At a temperature of approximately 70° C., slowly add 10 ml. of $(NH_4)_2HPO_4$ solution (15-percent). Add concentrated NH_4OH slowly until the precipitate is formed, then add excess. Let stand over night, stirring vigorously several times and also just before filtering. Filter through a Gooch crucible or a No. 42 Whatman paper, or paper of equivalent quality and wash with cold NH_4OH (1:10). Ignite to constant weight and weigh as $Mg_2P_2O_7$. If the alkalinity is appreciable and the total magnesium low, this should be calculated as $Mg(OH)_2$. Any balance of magnesium over total alkalinity would be $MgCl_2$.

Percentage of $Mg(OH)_2$ = grams of $Mg_2P_2O_7$ × 0.524 × 10
Percentage of $Mg(OH)_2$ × 34.3 = milliliters of 0.1 *N* HCl due to $Mg(OH)_2$

If the alkalinity titration with phenolphthalein was stopped and the milliliters recorded with the brilliant pink faded, the milliliters represent actual calcium hydroxide present.

Percentage of $Ca(OH)_2$ = milliliters of 0.1 *N* HCl × 0.0037 × 10

The difference (MeO − Ph) minus cubic centimeters due to $Mg(OH)_2$ equals the milliliters due to $CaCo_3$.

Percentage of $CaCO_3$ = milliliters of 0.1 *N* HCl due to $CaCO_3$ × 0.0050 × 10
Percentage as $CaCl_2$ = (milliliters for $Ca(OH)_2$ + milliliters for $CaCO_3$) × 0.00555 × 10

Deduct this latter percentage from total calcium as net $CaCl_2$.

NOTE.—If a large amount of $MgCl_2$ (2 or 3 per cent) is present the calculation of $CaCO_3$ will be inaccurate.

TOTAL ALKALI CHLORIDES AS SODIUM CHLORIDE

3. The chlorides KCl and NaCl shall be determined together. Where it is desired to distinguish between them, the potassium may be determined by any desired method and the two reported separately. The perchlorate method shall be used for this determination. For routine work the KCl and NaCl shall be reported as percentage of NaCl. The method used shall be as follows:

Dissolve an 8.000-g. sample (see Note 1) in 50 ml. of hot water, add 1 g. of c.p. $Ca(OH)_2$, mix well and boil gently for a minute. Dilute to exactly 100 ml. in a volumetric flask. Filter through a dry paper, discarding the first 10 ml., pipette a 25.00-ml. aliquot, add 20 ml. of water; heat to boiling and add 50 ml. of hot $(NH_4)_2C_2O_4$ (5-per-cent) or $(NH_4)_2CO_3$ (4-per-cent) preferably the latter. Make up to volume and mix well. Let stand till temperature is about that of the room and adjust the volume. Finally, filter through a dry retentive filter paper. Add a few milliliters of $(NH_4)_2C_2O_4$, heat to boiling, and filter. If the filtrate is not clear, refilter, discarding the first 10 ml. Pipette 25.00-ml. aliquot in 250-ml. beakers and add 1 ml. of concentrated HCl. Evaporate to dryness on a steam bath. Thoroughly ignite in a muffle or heat-treating furnace (see Note 2) at a temperature of from 300 to 350° C. In about 30 minutes, organic and ammonium salts should have been driven off. Cool, dissolve in 10 ml. of water, add 3 drops of Na_2CrO_4 or K_2CrO_4 (5-per-cent) solution as indicator, and titrate with 0.02 *N* $AgNO_3$ (see Note 3) to a pink end point. If the ignition was correctly done, there will be but little brown or yellow coloration due to charred organic residue to interfere with seeing the end point. Run a blank on the reagents used. If this is less than 0.5 ml. neglect it, if over 0.5 ml. subtract from the titration after deducting 0.5 ml. (1.00 ml. of 0.02 *N* $AgNO_3$ is equivalent to 0.00117 g. NaCl). In the method as given, 0.5000 g. of sample is finally titrated.

Percentage of NaCl = milliliters 0.02 *N* $AgNO_3 \times 0.00117 \times 1.05 \times 100 \div 0.5000$

or

Percentage of NaCl = milliliters 0.02 *N* $AgNO_3 \times 0.246$.

RAPID TECHNICAL METHOD

4. For ordinary purposes, where the quantity of material purchased does not warrant the employment of the foregoing method of

analysis, calcium chloride is deemed as satisfactory if the total chlorides present determined by titration with 0.1 *N* $AgNO_3$ and calculated to $CaCl_2$ is in excess of 78 per cent and if not more than a slight precipitate of $Mg(OH)_2$ appears when a 10-per-cent filtered solution of the material is made alkaline with $NH_4(OH)_2$.

No material shall be rejected under this technical method of analysis and in case the calcium chloride does not come up to the standards given it shall be analyzed by the methods described in Sections 2 and 3, inclusive.

EXPLANATORY NOTES

NOTE 1.—Instead of weighing out separate samples as indicated in Sections 1, 2, and 3, a 25-g. sample may be diluted to a volume of 100 ml., and 1 ml. of this solution used for the procedure in Section 1, 40 ml. for the procedure in Section 2, and 32 ml. for the procedure in Section 3. The 1 ml. should be measured with a standard calibrated pipette, and the 40 ml. and 32 ml. with a burette. These volumes shall then be further diluted to conform to the concentrations indicated under Sections 1, 2, and 3. This handling will render accurate distribution of the insoluble $Mg(OH)_2$ and $CaCO_3$ present more difficult than using direct weighed samples.

NOTE 2.—In case a muffle or furnace with close heat control is not available, a moderate bunsen flame played over the beaker may be used to volatilize the ammonium and organic compounds. In this case it would be advisable to control the determination by means of a known mixture having NaCl present in the same magnitude.

NOTE 3.—The 0.02 *N* $AgNO_3$ may be conveniently made by diluting 50.00 ml. of exactly 0.1 *N* solution to a 250-ml. volume. There is an empirical correction to be made on the factor which amounts to the 0.02 *N* value multiplied by about 1.05. This can be determined exactly by running on known mixtures having the same magnitude composition as the calcium chloride to be analyzed.

REPORT OF COMMITTEE D-5

ON

COAL AND COKE

Committee D-5 on Coal and Coke held one meeting during the past year at Pittsburgh, Pa., on March 16, and another will be held at the annual meeting of the Society prior to the presentation of this report. The committee is recommending this year for advancement to standard the Tentative Method of Test for Size of Anthracite (D 310 – 29 T) with a revision in the location of sampling points for collecting samples of anthracite from tops of loaded cars. The present Tentative Definition of the Term Coke (D 121 – 30 T) is being continued as tentative pending consideration of a proposal by Committee D-2 on Petroleum Products and Lubricants that the term "coke" without qualifying adjective may be the product from coal, pitch, or petroleum.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee II on Nomenclature and Definitions (H. C. Porter chairman).—This subcommittee, with the cooperation of Committee D-2 on Petroleum Products and Lubricants and the Power Test Code Committee of the American Society of Mechanical Engineers, has undertaken the preparation of definitions of "gross calorific value" and "net calorific value" of fuels. Gross calorific values are those obtained by burning fuels in bomb calorimeters as distinguished from net calorific values calculated from the gross and approaching more closely the total heat liberated when the fuel is burned in industrial furnaces. The net calorific values are especially important in comparing heating values of solid and liquid fuels.

Subcommittee VIII on Foundry Coke Specifications (J. T. MacKenzie, chairman).—This subcommittee reported at the meeting of Committee D-5 held during the annual meeting, some experiments being conducted by R. M. Fowler of the U. S. Bureau of Standards on the ability of pulverized coke samples, with a view to preparing such samples as standard samples for checking the volatile matter determination of coke. The results show that volatile matter increases in case the samples are exposed for long periods to the air of the laboratory, but that the volatile matter remains constant if the coke sample is kept in tightly stoppered containers. The tests by exposure to the air were conducted by allowing air to circulate continuously over the coke samples. Further tests are to be made in which the pulverized coke will be placed in stoppered containers and the stoppers removed from time to time so the exposure to air will be comparable to conditions under which the sample would be subjected in the laboratory if used as a standard. The stability test results appear in the Appendix to this report by Mr. Fowler, entitled "Stability Tests on Semet-Solvay Coke for Standard Sample."

Subcommittee IX on Coke Sampling (O. O. Malleis, chairman).—Considerable progress has been made in formulating methods of sampling coke for analysis and the subcommittee hopes soon to present a method for consideration as a tentative standard.

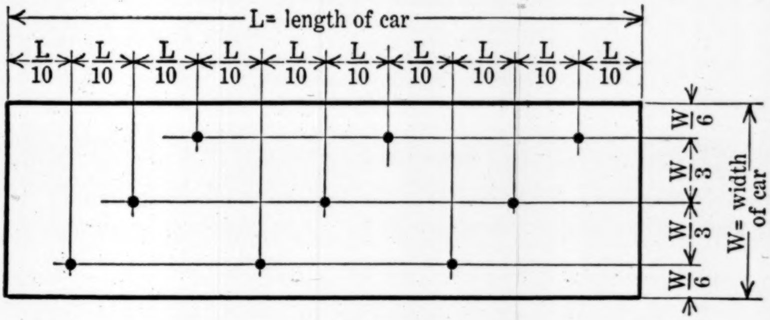

FIG. 1.—Location of Sampling Points from Exposed Surface of Car.

Progress is being made by the subcommittees on sampling tolerances, agglutinating value and pulverizing characteristics of coal, but the work of none of these groups has progressed far enough to warrant the submission of reports or recommendations.

RECOMMENDATIONS AFFECTING STANDARDS

Tentative Method of Test for Size of Anthracite (*D 310 - 29 T*).[1]—This tentative standard covers screen tests of anthracite to determine the percentage of undersize or oversize in any given commercial size. The committee recommends that the method be advanced to standard with the following change in the location of sampling points in case it is necessary to collect the sample from the exposed surface of a car. This change consists of staggering the sampling points to more nearly conform to the distribution of the coal as loaded:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 708 (1929); also 1930 Book of A.S.T.M. Tentative Standards, p. 469.

Section 6 (*b*).—Change from its present form: namely,

(*b*) In case it is necessary to collect the sample from the exposed surface of the car, at least nine equal increments shall be taken about one foot below the surface at regular intervals along three parallel lines running from one end of the car to the other. One of these lines shall pass through the center of the car and each of the other lines shall be about two-thirds the distance from the center line to the side of the car.

to read as follows:

(*b*) In case it is necessary to collect the sample from the exposed surface of the car, nine equal increments shall be taken about one foot below the surface. The nine sampling points shall be located as shown in Fig. 1.

Results of the letter ballot of the committee concerning the recommendation made in this report are given in the following table:

Item	Affirmative	Negative	Not Voting
ADVANCEMENT OF TENTATIVE STANDARD TO STANDARD			
Tentative Method of Test for Size of Anthracite (D 310 – 29 T), as revised	33	0	8

This report has been submitted to letter ballot of the committee, which consists of 41 members; 38 members returned their ballots all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

W. A. SELVIG,
Secretary.

H. C. PORTER,
Vice-Chairman.

EDITORIAL NOTE

The Tentative Method of Test for Size of Anthracite was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931, and appears in the 1931 Supplement to Book of A.S.T.M. Standards, page 95.

APPENDIX

STABILITY TESTS ON SEMET-SOLVAY COKE FOR STANDARD SAMPLE

By R. M. Fowler[1]

The sample of coke as received was well mixed by tumbling, then quartered to 320 g. This portion was sieved and the following fractions separated:

	Per Cent
Retained on No. 60 sieve	1.0
" " No. 100 " , passing No. 60 sieve	29.5
" " No. 200 " , " No. 100 "	28.8
" " No. 325 " , " No. 200 "	23.5
Passing No. 325 "	17.2

Volatile matter was determined by the Bureau of Mines method, by heating 1-g. samples in a covered platinum crucible at 950° C. for 7 minutes in a covered furnace.

Moisture was determined on separate 1-g. portions by heating at 105° C. to 110° C. for 1 hour.

Determinations were made on May 9, 1930, on the No. 60 to 100 (250 to 149-micron) material and the material that passed a No. 325 (44-micron) sieve. These samples were then exposed for 38 days in desiccators, ventilated with dust-free laboratory air, by means of an aspirator arrangement. One-half of each sample was placed in a desiccator inside of the laboratory while the other was placed outdoors. This latter one had direct sunlight until noon every day, while the one inside was never exposed to sun. On June 16, 1930 (after 38 days) the desiccators were opened and the samples mixed, bottled and the moisture and volatile matter determined as before. The samples were again replaced in the desiccators and air passed as before until March 25, 1931 (after 321 days) when they were removed and moisture and volatile matter again determined. The results are shown in Table I. The portions marked unexposed were kept in glass-stoppered bottles in a covered glass container located in a balance room.

Table I.—Stability of Volatile Matter in Semet-Solvay Coke.

Sample	Treatment	Originally		After 38 Days		After 321 Days	
		Moisture, per cent	Volatile Matter, per cent	Moisture, per cent	Volatile Matter, per cent	Moisture, per cent	Volatile Matter, per cent
Coarse, Nos. 60 to 100	Unexposed	0.14	0.47	0.14	0.50	0.21	0.44
Coarse, Nos. 60 to 100	Exposed inside	....	....	0.38	0.51	0.15	0.65
Coarse, Nos. 60 to 100	Exposed outside	....	....	0.35	0.45	0.44	0.93
Fine, No. 325	Unexposed	0.44	1.17	0.39	1.10	....	....
Fine, No. 325	Exposed inside	....	....	0.94	1.18	0.46	1.49
Fine, No. 325	Exposed outside	....	....	0.71	1.23	1.02	1.42

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[1] Chemist, U. S. Bureau of Standards, Washington, D. C.

REPORT OF SECTIONAL COMMITTEE
ON
CLASSIFICATION OF COALS

During the past year the Sectional Committee on Classification of Coals, functioning under the procedure of the American Standards Association, has continued to collect facts and data on the composition, properties, and uses of North American coals. This phase of the work is now drawing to a close and the grouping of coals into tentative classes has been started under the direction of W. T. Thom, Jr., Professor of Geology at Princeton University and Secretary of the Technical Committee on Scientific Classification. A fund of $2200 has been subscribed by companies and individuals towards defraying the cost of assistance in tabulating, classifying, and charting the data on classification. Mr. Thom is contributing his own time and Princeton University has allotted $500 of departmental funds to the work. Material assistance has been given also by Governmental Bureaus, the National Coal Association, and private corporations with whom members of the sectional committee are connected.

Contact with the Associate Committee on Coal Classification of the National Research Council of Canada has been continued with the result that the work has been effectively distributed and duplication avoided.

The three technical committees held two group meetings, in Washington, D. C., on November 25, 1930, and in Pittsburgh, Pa., on March 16 and 17, 1931, at the time of the annual meeting of the sectional committee. The next group meeting of the technical committees will be held in Pittsburgh in November, 1931, at the time of the International Coal Conference of the Carnegie Institute of Technology.

The committee reports with deep regret the death of Messrs. D. MacArthur, member-at-large, S. W. Parr, representing the American Chemical Society, and W. R. Addicks, representing the American Gas Association and vice-chairman of the sectional committee. Professor Parr was the recognized leader of coal chemistry in America. His method of classifying coal will probably form the basis of the system being developed by the committee. Mr. Addicks was a staunch supporter of the classification project and his counsel was most helpful.

Mr. C. E. Dobbin, alternate, representing the U. S. Geological Survey resigned on account of being transferred to Denver, Colo., and his place has been filled by the appointment of Mr. T. A. Hendricks also of the Geological Survey.

Technical Committee on Marketing Practice (F. R. Wadleigh, chairman).—The Technical Committee on Marketing Practice did not hold any separate meetings during the past year, but has met with the Technical Committee on Use Classification and has served in an advisory capacity.

Technical Committee on Use Classification (W. H. Fulweiler, chairman).—The Technical Committee on Use Classification of Coal held one meeting in Pittsburgh, Pa., on March 17, 1931. In cooperation with the Fuel Committee of the National Association of Purchasing Agents a questionnaire has been prepared requesting data on reasons why the particular coals being used in a given steam plant are considered best adapted for the conditions under which they are being used. Test data, where available, description and analysis of coal, type of stoker, and kind of furnace, are included in the questionnaire, which is to be sent out by the National Association of Purchasing Agents. The committee plans to collect data on the preferred characteristics of coal suitable for non-ferrous metallurgical industries; for cement burning; and for domestic use, in particular small domestic stokers; also data will be collected on the upper limit of volatile matter permitted in "smokeless coal."

Technical Committee on Scientific Classification (H. J. Rose, chairman).—The Technical Committee on Scientific Classification held two well-attended meetings in the past year. The conduct of experimental work and collection of data has been continued by the various subcommittees. However, this phase of the work has now reached the point where the actual charting of the different North American coals can be undertaken during the coming year.

The progress of the subcommittees of this technical committee during the past year is given below:

Subcommittee I on Nature, Location, and Mode of Occurrence of North American Coals has continued to assemble data on the analyses and physical properties of North American coals, through the help of other agencies. The U. S. Bureau of Mines has completed a new survey of all the mines in the State of Washington and has published the analyses.[1] A subsequent technical paper from the same bureau will give the friability, slacking index, agglutinating value, and low-temperature carbonization assay of Washington coals.

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[1] *Technical Paper No. 491*, U. S. Bureau of Mines (1931).

A similar survey for Iowa has been made by the Iowa Geological Survey and published.[1] The Alberta coals are being studied by the Associate Committee on Coal Classification of the National Research Council of Canada. During the coming year the U. S. Bureau of Mines will cooperate with the Research Department of the Anthracite Institute in a survey of the physical and chemical properties of representative sections of the Pennsylvania anthracite field. The U. S. Geological Survey plans to fill in certain gaps that exist in the twilight zones between the different ranks of coal.

Subcommittee II on Methods of Analysis, Origin and Composition of Coal has completed experimental work in the development of an accelerated slacking test of coal. The method is described and the relation of slacking index to the analysis and rank of a number of typical coals is given in a Bureau of Mines Report.[2]

The investigation of the Parr and modified Parr[3] formulas for computing the mineral matter in coal from the ash, and of the Stansfield graphical method has been completed by the U. S. Bureau of Mines and is being prepared for publication. In the absence of carbonates and other disturbing factors both formulas agree fairly well with the graphical method. The Parr formula tends to give results slightly below the graphical method and the modified formula somewhat above. On the whole there appears to be no advantage in modifying the original Parr formula.

Fish and Addlestone[4] of the Virginia Polytechnic Institute cooperated with the subcommittee in applying the Parr and modified Parr formulas to Virginia coals. They find that neither formula gave as good agreement in unit values as expected until correction was made for the carbon dioxide content of the coals. Correcting for carbon dioxide the original Parr formula gave slightly better agreement than the modified formula.

Although tentative methods for determining friability and agglutinating properties of coal have been used, these methods are not fully standardized. The Bureau of Mines is conducting an investigation of these methods at both the Seattle and Pittsburgh Experiment Stations. Also microscopic studies bearing on the types and the origin of coal are being continued at the latter station.

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[1] *Technical Paper No. 2*, Iowa Geological Survey (1930).

[2] A. C. Fieldner, W. A. Selvig and W. H. Frederic, "Accelerated Slacking Test for Determination of Slacking Characteristics of Coal," *Report of Investigations No. 3055*, U. S. Bureau of Mines (1930).

[3] Modified for organic sulfur.

[4] F. H. Fish and J. A. Addlestone, "Unit Coal Studies on Some Virginia Coals," *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 3, p. 155 (1931).

Subcommittee III on Present and Proposed Systems of Classification has completed its assignment and has been discharged. The subcommittee made a comprehensive study of all the existing systems for classifying coal and developed a scheme for comparing the position of various coals in these systems by means of the Rose Multibasic Coal Chart.

A new committee known as Subcommittee IV on Tentative Classification of Coals under the chairmanship of Mr. W. T. Thom, Jr., has been created. This committee is now engaged in plotting some 10,000 analyses of American coals on the multibasic coal charts.

In order to secure publication and discussion of the work of the various subcommittees during the past two years, arrangements have been made to hold another symposium on the classification of coals at the annual meeting of the American Institute of Mining and Metallurgical Engineers in New York in February, 1932.

Respectfully submitted on behalf of the sectional committee,

A. C. FIELDNER,
Chairman.

C. B. HUNTRESS,
Secretary.

REPORT OF COMMITTEE D-7
ON
TIMBER

Committee D-7 on Timber through its various subcommittees reports the following detailed activities:

Subcommittee I on Specifications for Timber (C. E. Paul, chairman).—This subcommittee has considered the Tentative Specifications for Timber Piles (D 25 – 30 T) and has received a number of constructive suggestions which it is hoped will lead to a final recommendation next year.

Subcommittee VI on Timber Preservatives (S. R. Church, chairman).—The activities of Subcommittee VI during the year are presented in its report appended hereto. The subcommittee is proposing for immediate adoption as given later in the report a revision of the Standard Method of Test for Distillation of Creosote Oil (D 246 – 30). The work leading to this recommendation has been carried on in cooperation with the Preservatives Committee of the American Wood Preservers' Association.

The subcommittee recommends a continuation as tentative of the Tentative Method of Test for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 – 30 T) and also the Tentative Definitions of Terms Relating to Timber Preservatives (D 324 – 30 T).

Subcommittee XI on Moisture Content of Timber (M. E. Dunlap, chairman).—Within the past year, the apparatus known as the blinker which was developed at the Forest Products Laboratory, reached a stage of commercial development. It is being produced by the American Instrument Co., Washington, D. C.; General Electric Co., Schenectady, N. Y.; and L. A. Millbrook, Maywood, Ill. It is not known just how many instruments are in commercial use. Several are in use in cooperage plants with satisfactory results.

The Tag-Heppenstall moisture meter, made by the C. J. Tagliabue Co., Brooklyn, N. Y., has been improved during the year and is now quite extensively used. Special electrodes have been designed for testing the moisture content of veneers. By the use of a large number of points and an increase in the sensitivity of the instrument at lower moisture contents, moisture in veneers can be measured as low as 3.5 or 4.0 per cent.

An instrument known as the sliver machine has been developed at the Forest Products Laboratory to indicate the moisture which wood is approaching in workrooms or conditioning rooms. Quite a large number of these machines are in use. A simple beam scale is used with a standard sample of thin wood suspended from it having an oven-dry weight of 100 g. The instrument is read by balancing the scale and observing the additional weight above 100 g. required. This amount represents the moisture content.

With this group of instruments available, it will probably be possible for the committee to consider the results being obtained in practical applications during the coming year.

The Tentative Specifications for Timber Piles (D 25 – 30 T) are under active consideration by the committee and as a result of this it is expected that a final report will be made next year.

In view of the constructive suggestions received by the committee concerning the Tentative Definitions of Terms Relating to Timber Preservatives (D 324 – 30 T) it was thought desirable to continue these definitions as tentative for another year. As mentioned in the report of Subcommittee VI, appended hereto, it is recommended that the Tentative Method of Test for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 – 30 T) be continued as tentative for another year because of the necessity for further work.

This report has been submitted to letter ballot of the committee which consists of 25 members; 24 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

REPORT OF SUBCOMMITTEE VI ON TIMBER PRESERVATIVES

The subcommittee held one meeting during the year at Chicago on March 11.

In the report of this subcommittee in 1930[1] there was presented a report from the U. S. Bureau of Standards giving results of determinations on the density and thermal expansion of coke-oven tars, undertaken under the auspices of a joint conference committee as a continuation of the previously reported determinations on creosote.

It was stated also that the joint conference committee had requested the Bureau of Standards to prepare tables for various creosote - coal tar solutions, containing from 20 to 50 per cent coal-tar.

The Bureau of Standards has recently suggested that instead of preparing such tables, that Group II of the creosote tables,[2] which gives the corrections for creosote having a specific gravity above 1.09, be taken as applicable to all creosote coal-tar solutions. This suggestion was not received in time for consideration by the subcommittee or the joint conference committee, to take action this year.

The Preservatives Committee of the American Wood Preservers' Association, as a result of a large number of comparative tests by different operators working on the same creosote in one laboratory, has recommended that the distillation test be revised with respect to the requirement for dehydration and as regards the permissible variation in time of distillation and rate of flow of distillate.

This subcommittee has for the present withheld its approval of these changes. It is proposed during the coming year to make a careful comparison of the entire Standard Method of Test for Distillation of Creosote Oil (D 246 – 30) with the corresponding procedure appearing in the standards of the American Wood-Preservers' Association and of the American Railway Engineering Association. It is obviously desirable that these three organizations should be in complete accord as to the details and wording of this important method. It is known that there are at present a number of slight differences in the three methods. It was decided to await an opportunity for a careful study of all parts of the method before recommending any further alterations to our present standards.

A communication was received from Committee D-15 on Thermometers conveying a request from the Association of Scientific

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 820 (1930).

[2] See *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1282 and 1283 (1930).

Apparatus Manufacturers for a greater tolerance in the accuracy limits of the standard high-distillation thermometer specified in the Standard Method D 246, particularly in the upper range. This subcommittee has carefully considered the request and finds that its members have experienced no difficulty in buying thermometers within the limits specified and believes that it would be a great mistake to sacrifice the accuracy that now exists in the output of at least a number of thermometer makers.

The subcommittee recommends that the following tentative standards under its jurisdiction be continued as tentative:

Tentative Method for the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 – 30 T);

Tentative Definitions of Terms Relating to Timber Preservatives (D 324 – 30 T).

Respectfully submitted on behalf of the subcommittee,

S. R. Church,
Chairman.

REPORT OF COMMITTEE D-8

ON

BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

During the past year Committee D-8 has organized two new Subcommittees, one on Bituminous Joint Compounds for Sewer Pipe under the chairmanship of J. M. Weiss and the other on Coefficient of Expansion of Bituminous Materials under the chairmanship of J. S. Miller, Jr.

Subcommittee VII on Refined Ductility Tests for Roofing Materials (Lester Kirschbraun, chairman), and Subcommittee VIII on Accelerated Weathering Tests (O. G. Strieter, chairman), have been very active in securing valuable information by means of cooperative work. These investigations have not progressed to a point that would warrant the committee in making definite recommendations to the Society, but the work has been sufficiently comprehensive and of such importance as to warrant publication. Reports of these subcommittees are accordingly appended to this report.

Upon recommendation by the committee in 1930, the Standard Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules, Likewise Asphalt Shingles Surfaced with Mineral Granules (D 228 – 27) were withdrawn and published as tentative Methods D 228 – 30 T.[1] This action was taken to pave the way for submission of a complete revision of the methods in order to make them more generally applicable and to meet certain criticisms that had been received. During the past year, such revision has been effected. It is therefore recommended that the new proposed Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Finc Talc, Granular Talc, or Mineral Granules; Also Asphalt Shingles Surfaced with Mineral Granules, appended hereto,[2] be approved as a revision of the existing methods and published as tentative.

The results of the letter ballot of the committee upon the recommendation made in this report, are given in the following table:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 827, 1155 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 500.

[2] See p. 818.—Ed.

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF TENTATIVE STANDARD Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules, Likewise Asphalt Shingles Surfaced with Mineral Granules (D 228 - 30 T)........	33	1	5

This report has been submitted to letter ballot of the committee, which consists of 43 voting members; 39 members returned their ballots, of whom 34 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

S. T. WAGNER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revised Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine Talc, Granular Talc, or Mineral Granules; also Asphalt Shingles Surfaced with Mineral Granules were accepted. The methods in their revised form appear on page 818.

REPORT OF SUBCOMMITTEE VII ON REFINED DUCTILITY TESTS FOR ROOFING MATERIALS

Subcommittee VII on Refined Ductility Tests for Roofing Materials has been quite active during the year and has conducted a series of ductility tests on four types of asphalts. The materials used in the investigation were as follows: Indian asphalts of two grades having melting points of 175° F. and 220° F., respectively; Venezuelan asphalts with melting points of 175° F. and 220° F.; Californian asphalts having melting points of 175° F. and 220° F.; and Mexican asphalts with melting points of 176° F. and 223° F.

Table I.—Comparison of Ductility Results of Various Asphalts at Different Temperatures.

	Ratio of Average Ductilities			Maximum Deviations from Average Ductility											
				At 77° F.				At 115° F.				At 140° F.			
				Over		Under		Over		Under		Over		Under	
	At 77° F.	At 115° F.	At 140° F.	cm.	per cent	cm.	per cent	cm.	per cent	cm.	per cent	cm.	per cent	cm.	per cent
Indian Asphalt, 175° F. melting point.........	1	2.0	5.0	0.32	9.7	0.53	16.2	0.77	12.2	1.03	16.3	4.36	27.8	2.89	18.5
Indian Asphalt, 220° F. melting point.........	1	1.80	2.34	0.4	25.0	0.2	12.5	0.22	7.6	0.18	6.3	0.28	7.4	0.57	15.1
Venezuelan Asphalt, 175° F. melting point......	1	3.05	9.80	0.28	6.6	0.32	7.5	2.46	18.9	1.54	11.8	6.03	14.4	12.67	30.2
Venezuelan Asphalt, 220° F. melting point......	1	1.36	2.09	0.85	27.0	0.35	11.1	0.44	10.2	0.41	9.51	0.89	13.5	0.71	10.7
California Asphalt, 176° F. melting point......	1	4.53	15.39	0.36	8.9	0.34	8.4	3.18	17.3	5.42	29.6	37.8	60.8	31.7	50.9
California Asphalt, 220° F. melting point......	1	2.01	3.01	0.23	12.3	0.47	25.1	0.77	20.4	0.58	15.3	0.86	15.2	1.14	20.2
Mexican Asphalt, 176° F. melting point......	1	2.85	6.65	0.62	12.1	0.43	8.4	1.12	7.7	1.33	9.1	7.86	23.0	14.64	42.9
Mexican Asphalt, 223° F. melting point......	1	1.52	2.47	0.36	11.5	0.34	10.8	0.92	19.3	0.58	12.1	0.92	13.5	0.93	13.6

The ductility of the various asphalts was determined at 77, 115, and 140° F., in accordance with the following procedure:

The material to be tested was placed in an oven at a temperature of 325° F. for not more than one hour, or until the contents were uniformly heated. The sample in which a thermometer had been placed was then removed to a sand bath and brought to a temperature of not over 400° F., while constantly stirring, until the material was sufficiently liquid to be poured into the mold. The molds so prepared were cooled to room temperature, and the excess material shaved off with a hot knife. The samples thus prepared were then

TABLE II.—RESULTS OF REFINED DUCTILITY TESTS ON FOUR TYPES OF ASPHALTS.

	INDIAN ASPHALT, 175° F. MELTING POINT						INDIAN ASPHALT, 220° F. MELTING POINT						VENEZUELAN ASPHALT, 175° F. MELTING POINT						VENEZUELAN ASPHALT, 220° F. MELTING POINT					
Company	Ductility at 77° F., cm.	Average	Ductility at 115° F., cm.	Average	Ductility at 140° F., cm.	Average	Ductility at 77° F., cm.	Average	Ductility at 115° F., cm.	Average	Ductility at 140° F., cm.	Average	Ductility at 77° F., cm.	Average	Ductility at 115° F., cm.	Average	Ductility at 140° F., cm.	Average	Ductility at 77° F., cm.	Average	Ductility at 115° F., cm	Average	Ductility at 140° F., cm.	Average
American Tar Products Co.	3.2^{a} 3.2^{a} 3.5^{a}	3.3	5.4^{a} 5.3^{a} 5.3^{a}	5.3	13.3^{a} 14.6^{a} 13.9^{a}	13.9	1.7$^{a, b}$ 1.4^{a} 1.4^{a}	1.5	2.7 2.8 2.6	2.7	3.3 3.2 3.0	3.2	4.2 3.9 4.0	4.0	12.1 12.0 9.5	12.1	38.6 44.7 40.7	41.3	2.8 3.2 3.0	3.0	4.0 4.1 3.9	4.0	6.0 5.8 5.8	5.9
Barber Asphalt Co....	2.7 2.8	2.75	7.0 7.2	7.1	19.5 17.5	18.5	1.5^{b} 1.5^{b}	1.5	2.8 2.8	2.8	4.0 4.0	4.0	4.1 4.2	4.15	14.0 16.0	15.0	51.0 44.0	47.5	2.8 2.8	2.8	4.2 4.2	4.2	7.2 7.2	7.2
The Barrett Co..........	3.5 3.7	3.6	5.5 5.5	5.5	12.0 13.5	12.75	1.5 1.5	1.5	3.0 3.0	3.0	4.0 4.0	4.0	4.5 4.5	4.5	12.0 13.0	12.5	43.0 44.5	43.75	3.0 3.2	3.1	4.5 5.0	4.75	6.0 6.0	6.0
Bird and Son	3.50 3.60	3.55	7.00 6.70	6.95	13.30 13.10	13.20	1.7 1.7	1.7	3.00 3.20	3.10	4.0 4.1	4.05	4.6 4.5	4.55	11.40 11.90	11.65	30.50 28.10	29.30	3.25 3.20	3.22	4.50 4.50	4.50	6.80 6.40	6.60
Flintkote Co.	3.0 3.0	3.0	6.8 6.7	6.75	18.0 13.0	15.5	1.4^{b} 1.4^{b}	1.4	2.7 2.7	2.7	3.5 3.3	3.4	4.0 3.9	3.95	11.5 11.5	11.5	20+ 20+	20+	3.6 3.0	2.8	4.0 3.8	3.9	6.4 6.5	6.45
Dow & Smith..	3.5		6.5		20.0		2.0^{b}		3.0		4.0		4.5		15.5		48.0		4.0		4.5		7.5	
Average, all laboratories..	3.28		6.33		15.64		1.6		2.88		3.77		4.27		13.04		41.97		3.15		4.31		6.61	

	CALIFORNIA ASPHALT, 176° F. MELTING POINT						CALIFORNIA ASPHALT, 220° F. MELTING POINT						MEXICAN ASPHALT, 176° F. MELTING POINT						MEXICAN ASPHALT, 223° F. MELTING POINT					
American Tar Products Co.	3.8 3.7 3.8	3.8	13.3 12.5 17.8	12.9	43.1 37.8 39.8	40.2	1.5^{b} 1.4 1.4	1.4	3.2 3.3 3.2	3.2	4.4 4.5 4.5	4.5	4.8 4.7 4.7	4.7	13.6 13.0 13.3	13.3	18.2 21.0 19.4	19.5	2.9^{b} 3.1 3.0	3.0	4.1 4.3 4.2	4.2	6.0 5.9 5.8	5.9
Barber Asphalt Co....	4.0 4.0	4.0	21.0 19.0	20.0	100+ 100+	100+	2.0^{b} 2.0^{b}	2.0	3.5 3.5	3.5	5.8 6.0	5.9	5.0 5.1	5.05	14.0 16.0	15.0	33.0 43.0	38.0	3.0 3.0	3.0	4.4 4.4	4.4	7.0 6.8	6.9
The Barrett Co..........	4.5 4.2	4.35	20.0 20.5	20.25	30.0 31.0	30.5	2.0 2.2	2.1	4.0 4.0	4.0	6.5 6.5	6.5	5.0 5.0	5.0	15.0 16.5	15.75	29.0 35.5	32.25	3.0 3.5	3.25	5.0 5.0	5.0	7.0 7.0	7.0
Bird and Son	4.3 4.5	4.40	18.70 18.90	18.80	76.50 64.10	70.30	2.00 2.00	2.0	4.50 4.60	4.55	6.40 6.50	6.45	5.8 5.7	5.75	14.9 15.1	15.0	43.7 34.2	38.95	3.2 3.4	3.3	5.7 5.7	5.7	7.5 8.0	7.75
Flintkote Co.	3.7 3.7	3.7	16.3 16.6	16.45	20+ 20+	20+	1.7^{b} 1.7^{b}	1.7	3.5 3.4	3.45	5.4 5.6	5.5	4.8 4.8	4.8	13.5 14.0	13.75	20+ 20+	20+	2.9^{b} 2.7^{b}	2.8	4.3 4.5	4.4	6.6 6.3	6.45
Dow & Smith..	4.0		21.5		70		2.0^{b}		4.0		5.0		5.5		15.0		42.0		3.5		5.0		7.0	
Average, all laboratories..	4.04		18.32		62.20		1.87		3.78		5.64		5.13		14.63		34.14		3.14		4.78		6.83	

[a] Sample was compounded with other bitumens.

[b] Broke at center.

tested in accordance with the Tentative Method of Test for Ductility of Bituminous Material (A.S.T.M. Designation D 113 – 26 T),[1] the testing bath being maintained at the temperatures designated.

Results of the investigation are shown in Table II and a comparison of the average ductility values at temperatures of 77, 115 and 140° F. are shown in Table I.

Respectfully submitted on behalf of the subcommittee,

LESTER KIRSCHBRAUN,
Chairman.

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 26, Part I, p. 886 (1926); also 1930 Book of A.S.T.M. Tentative Standards, p. 448.

REPORT OF SUBCOMMITTEE VIII ON ACCELERATED WEATHERING TESTS

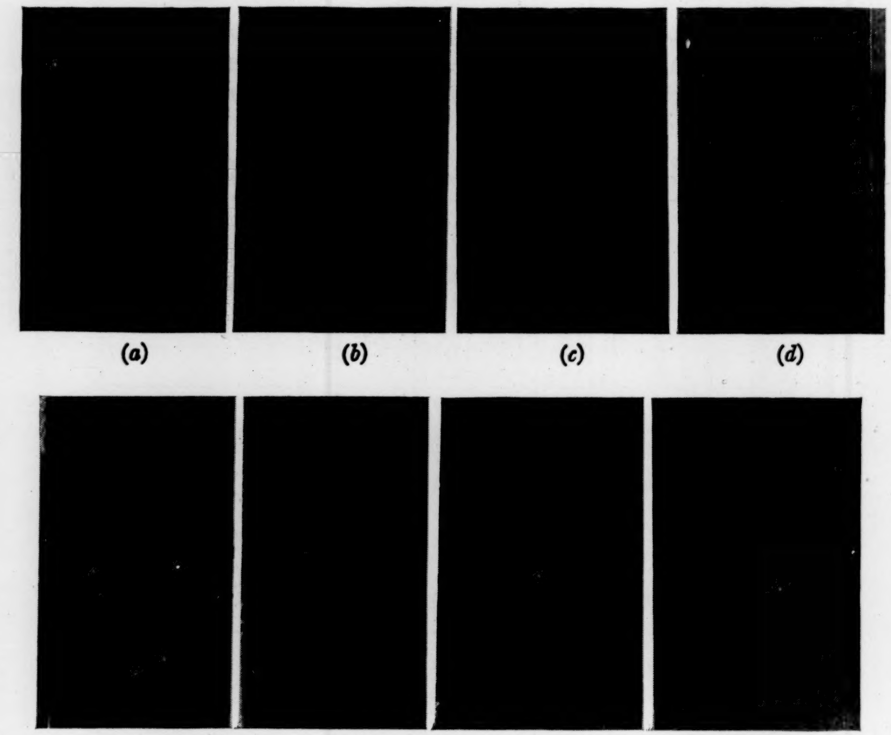
Since the formation of Subcommittee VIII on Accelerated Weathering Tests, cooperative experiments have been conducted to determine whether different operators using different machines could obtain similar results.

TABLE I.—RESULTS OF COOPERATIVE TESTS ON ACCELERATED WEATHERING TESTS.

	Current Consumption, kilowatt-hours	Line Voltage, volts	Arc Voltage, volts	Arc Amperage, amperes	Temperature of Panels during Light Cycle, deg. Fahr.	Detection of Differences in Behavior of Panels, cycles required	Final Breakdown of Panels	Refrigeration, deg. Fahr.	Appearance of Panels at the End of 15 Cycles
A. W. Beemer	307[a]	222 (60 cycles)	138–140	14.0–14.75 Ave. 14.4	118–140 Ave. 129	2	none	−2	Smooth, dulll. (See Fig. 1(*a*).) Smooth, slightly greasy. (See Fig. 2(*a*).)
S. B. Montgomery	400[b]	220–240 Ave. 230	140	10	140	5	none	−10	Smooth, dull, no cracks. Very faint configuration. (See Fig. 1(*b*).) Smooth, long sharp cracks, but not through to aluminum panel. (See Fig. 2(*b*).)
S. A. Montgomery	739[c]	210–220 a.c.	100	13	80–110	10	none	−10	Smooth. (See Fig. 1(*c*).) Smooth, slightly brown. (See Fig. 2(*c*).)
H. R. Snoke	782[c]	230 d.c.	149	10–13	127–154 Ave. 141	1	Panel B,[d] 14 cycles	−10	Smooth, dull. (See Fig. 1(*d*).) Contracted, cracked through to aluminum panel. (See Fig. 2(*d*).)
J. S. Miller, Jr.	405[a]	224 a.c.	118	14 (power line)	115	1	none	−5	Smooth, dull. (See Fig. 1(*e*).) Contracted, slightly. (See Fig. 2(*e*).)
L. Kirschbraun	....	....	138 a.c.	....	132–164 Ave. 143	..	Panel B,[e] 43 cycles	−10	At removal after 51 cycles the panel was smooth, chalking, negative to electrical conductivity test, no cracking. (Fig. 1(*f*) shows panel after 53 cycles exposure.) Contracted. Asphalt showed considerable healing power. Cracked through to aluminum panel after 43 cycles. (Fig. 2(*f*) shows panel after 53 cycles of exposure.
E. H. Berger	....	224–231 a.c. Ave. 228	111–132 Ave. 124	14.8	138	1	none	−10	Smooth, dull. No cracks. (See Fig. 1(*g*).) Contracted. (See Fig. 2(*g*).)
O. G. Strieter	763[c]	230 d.c.	149	10–13	137–160 Ave. 148	1	Panel B, 12 cycles	−10	Smooth, dull. No cracks. (See Fig. 1(*h*).) Contracted, cracked through to aluminum after 12 cycles. (See Fig. 2(*h*).)

[a] Across arc. [b] Mercury arc lamp. [c] Total from power line. [d] See Fig. 2(*d*). [e] See Fig. 2(*f*).

Two kinds of asphalts were used in these tests. The asphalts were chosen to give a striking difference in behavior when subjected to accelerated weathering. Test panels were of aluminum, 3 by 6 by $\frac{1}{16}$ in., and were coated to a thickness of 0.025 in., ±0.005 in. To secure uniformity, all panels were prepared at the Bureau of Standards by a member of the subcommittee. The total exposure was for 15 cycles, a single cycle being as follows:


(*a*) (*b*) (*c*) (*d*)

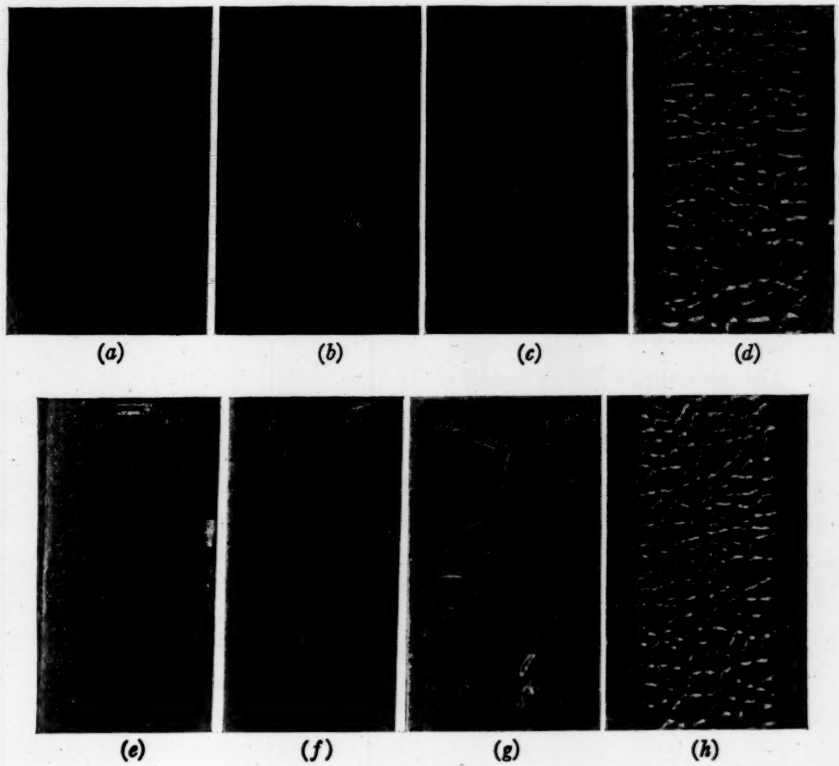
(*e*) (*f*) (*g*) (*h*)

FIG. 1.—Appearance of Panels of Asphalt A After Accelerated Weathering Tests (See Table I).

Cold	1¾ hours	8.45 A.M.	to	10.30 A.M.
Rain	1 hour	10.45 A.M.	to	11.45 A.M.
Light and heat	1½ hours	12.00 M.	to	1.30 P.M.
Rain	2 hours	1.45 P.M.	to	3.45 P.M.
Light	16½ hours	4.00 P.M.	to	8.30 A.M.

The test procedure was as follows:

The panels were placed for 1¾ hours in a refrigerator which had been previously cooled to −10° F. After refrigeration, the panels were placed in the cylinder of the weathering machine and vigorously sprayed with water (rain) for 1 hour. A rotating sprinkler was used for spraying and the temperature of the water was the same as it came from the tap. After spraying, the panels were exposed to the light and heat from a Fade-Ometer type carbon-arc lamp (one operator used a mercury-arc lamp), either direct or alternating current for $1\frac{1}{2}$ hours. The rain cycle was then repeated for 2 hours followed by $16\frac{1}{2}$ hours of light.


(*a*) (*b*) (*c*) (*d*)

(*e*) (*f*) (*g*) (*h*)

FIG. 2.—Appearance of Panels of Asphalt B After Accelerated Weathering Tests (See Table I).

Eight members of the subcommittee submitted reports on the cooperative tests. A summary of their results is given in Table I.

Examination of Table I shows that the test conditions differed considerably, the chief difference being in the total consumption of current, in the arc voltage and the temperature of the panels during the light cycle.

The results given in the last column of Table I are also shown by the photographs in Figs. 1 and 2. Asphalt A (Fig. 1), remained smooth, all panels presenting a fairly uniform appearance. Asphalt B (Fig. 2), with three exceptions, contracted and shows considerable grooving. The panels shown in Fig. 2(*a*) and (*c*) remained smooth, although slight differences in behavior were noticeable. The panel shown in Fig. 2(*b*), tested with a mercury arc lamp, remained smooth though entirely covered with surface cracks, however, too indistinct in the photograph for detection.

It is apparent from these tests that similar conditions of test are necessary if similar results are to be obtained. This is particularly demonstrated by the panels in Fig. 2(*d*) and (*h*) where the conditions of test were almost identical. However, such differences in results as are obtained by different test conditions are apparently differences in the degree and not in the kind of deterioration. This would indicate that the carbon arc lamp, whether direct or alternating current, and the mercury arc lamp will all produce similar results when brought to the same intensity.

The subcommittee will continue cooperative testing, but before making such tests all accelerated testing machines should be brought to operate under similar conditions.

Respectfully submitted on behalf of the subcommittee,

O. G. STRIETER,
Chairman.

REPORT OF COMMITTEE D-9
ON
ELECTRICAL INSULATING MATERIALS

Two meetings, each of two days duration, have been held by the committee and its subcommittees during the year, as follows:

At the Wardman Park Hotel, Washington, D. C., November 5 and 6, 1930;

At the A.I.E.E. Headquarters, Engineering Societies Building, New York City, March 5 and 6, 1931.

A third meeting will be held at Chicago, Ill., during the annual meeting of the Society previous to the presentation of this report.

The committee has reorganized its subcommittees for the purpose of unifying the work of the different subcommittees and of extending its work to insulating materials not now covered by the committee. The new subcommittees with the subjects to be covered and the chairmen for 1931–1932 are as follows:

Subcommittee I on Insulating Varnishes, Paints and Lacquers (F. T. Wright, chairman);

Subcommittee II on Molded Insulating Materials (A. M. Lynn, chairman);

Subcommittee III on Plates, Tubes and Rods (Dean Harvey, chairman);

Subcommittee IV on Insulating Mineral Oils (E. A. Snyder, chairman);

Subcommittee V on Ceramic Products (L. E. Barringer, chairman);

Subcommittee VI on Solid Filling and Treating Compounds (J. M. Wilson, chairman);

Subcommittee VII on Electrical Tests (E. S. Lee, chairman);

Subcommittee VIII on Insulating Papers and Fabrics (H. N. Van Deusen, chairman);

Subcommittee IX on Mica Products (M. P. Davis, chairman).

The subcommittees have advanced their work by holding additional meetings at times other than those at which the main committee met. Subcommittee III on Sheet Insulation has been most active in this respect.

The committee has been active in the development of new methods of testing insulating materials, in the improvement of the present standard or tentative standard methods, and in the preliminary drafting of specifications. The scope of the work is covered in detail in the following recommendations affecting methods of test and in the description of the activities of the subcommittees.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

Standard Methods of Testing Electrical Insulating Oils (D 117 – 27):[1]

A tentative revision of these methods, issued first in 1929 and revised last year, covers methods of sampling oil in tank cars, drums and other containers. The revision has proved satisfactory and consequently the committee recommends that the tentative revision consisting of Sections 1 to 8 as published in the 1930 report of this committee[2] be advanced to standard and substituted for Sections 1 to 7 of the Standard Methods of Testing Electrical Insulating Oils (D 117 – 27) renumbering the present Sections 8 to 19 accordingly.

Tentative Methods of Testing Insulating Varnishes (D 115 – 30 T):[3]

Further experience with these methods of test has indicated the desirability of a number of minor changes. The committee accordingly recommends that these methods be revised as follows and continued as tentative:

Section 5 (*a*).—Change this paragraph to read as follows by the addition of the italicized dimensions and the omission of those in brackets:

> 5. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about [3 cm. (1.18 in.)] *4 cm.* (*1.57 in.*) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

Section 6 (*b*).—Change the first sentence of this paragraph to read as follows by the addition of the italicized words:

> (*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger *at a point approximately 2 in. from the bottom* will not become obliterated by further flow of the material.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1004.

[2] See *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 830 and 1284 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 796.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1169 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 527.

Section 8.—Renumber Section 8 to 8 (*a*), change Paragraphs (*a*), (*b*) and (*c*) to items (*1*), (*2*) and (*3*), and add a new Paragraph (*b*) reading as follows:

(*b*) Much more information about a varnish can be obtained by making the test under all three conditions than by making it under only one condition. The relation which the dielectric strength tests for a given varnish show to one another, is of quite as much significance as the values for the different tests considered separately.

Section 10 (*a*).—Change this paragraph from its present form: namely,

10. (*a*) The dielectric strength of the specimen shall be determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased uniformly to breakdown in approximately 20 seconds. Ten such punctures are to be made at various points selected at random on each specimen. In each test the thickness of the specimen is to be determined as close to the point of puncture as practicable.

NOTE.—When necessary, in order to get ten punctures additional specimens should be tested.

to read as follows:

10. (*a*) The dielectric strength of the specimen shall be determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being too close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

Section 11 (*c*).—Change Note 1 following Paragraph (*c*) from its present form: namely,

NOTE 1.—Upon removal from the water, the surface water shall be wiped off and dielectric strength test made immediately.

to read as follows:

NOTE 1.—In testing specimens after immersion in water, only one specimen should be removed from the water at a time. The specimen after removal from the water should be carefully dried by placing between sheets of dry blotting paper and pressing down gently with the hand over the entire surface. If necessary, the blotting procedure should be repeated until the specimen is free from surface moisture. The specimen should then be tested immediately. If specimens are allowed to remain out of water for even a short time before testing, they dry out to a greater or less extent and the test is apt to be misleading.

Section 14 (a).—Insert the following Note after this paragraph:

NOTE.—Because of temperature variations between different levels in the oven, the specimen should be placed in the oven with the 8-in. dimension horizontal and the 1-in. dimension vertical. All specimens should be at the same level in the oven.

Section 15.—Designate the present Note as Note 1, and add the following as Notes 2 and 3:

NOTE 2.—The temperature of the oven should be held as closely as possible to the mean (107.5° C.). A difference of 5° C. in this temperature range, when continuously maintained, has a very considerable effect (approximately 25 per cent) on the life test of a varnish.

NOTE 3.—As the "grain" of the copper influences the result of the test, the heat endurance test specimens should be prepared by cutting the copper strips parallel with the direction of rolling.

Section 18.—Change from its present form: namely,

18. A strip of bond paper 0.064 mm. (2.5 mils) in thickness, 10.2 cm. (4 in.) in width and 50.8 cm. (20 in.) in length, shall be immersed in the varnish at a room temperature of approximately 20° C. (68° F.) up to a line previously drawn across the paper a few inches from the top. The paper shall be withdrawn at a slow and uniform rate (about 38 cm. (15 in.) per minute), care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

to read as follows:

18. A strip of sheet copper or brass about 4 cm. (1.57 in.) wide, 35 cm. (13.78 in.) long, and 0.127 mm. (0.005 in.) thick, shall be immersed in the varnish at a room temperature of approximately 20° C. (68° F.) up to a line previously drawn across the strip 1 in. from the top. The sheet shall be withdrawn at a slow and uniform rate (about 38 cm. (15 in.) per minute), care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

Sections 21 and 22. Evaporation Test.—The value of the evaporation test has been questioned and the committee accordingly recommends that Sections 21 and 22 be deleted and the remaining sections renumbered accordingly.

Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 30 T):[1]

A study has been made of methods for testing laminated sheet materials for dielectric strength both at room temperature and at elevated temperatures. As the result of these studies the committee proposes the following additions to these test methods and recommends that the methods as thus revised be continued as tentative:

Section 1.—After the last paragraph of this section insert the following:

Sheet materials are divisible into two general classes: (1) thin, flexible materials, easily bent or wrapped around conductors, and (2) laminated materials, slightly flexible or rigid.

> Tests on thin flexible materials at room temperature shall be made in accordance with Method *A*. Short-Time Dielectric Strength Tests as specified in Sections 2 to 12; with Method *B*. One-Minute Step-by-Step Dielectric Strength Test as specified in Sections 13 to 22, or with Method *C*. Endurance Dielectric Strength Test as specified in Sections 23 to 28.
>
> Tests on laminated sheet materials at room temperature shall be made in accordance with the special instructions covered under Dielectric Strength Tests on Laminated Materials in Sections 29 to 32.

Special Instructions for Laminated Sheet Materials.—Add the following special instructions for laminated sheet materials after Section 28:

Dielectric Strength Tests on Laminated Materials

29. For testing laminated sheet materials the procedure described in Method A, Short-Time Tests, Sections 2 to 12 and Method B, Step-by-Step Test, Sections 13 to 22 shall be modified in accordance with Sections 30 to 32.

30. *Surrounding Medium.*—All tests shall be made under oil maintained at normal room temperature.

31. *Position of Electrodes and Specimen.*—Tests may be transverse or parallel to the laminations, or both, depending upon whether the stress on the material when in use is to be transverse or parallel to the laminations, or both.

(*a*) Transverse tests shall be made between the standard 2-in. electrodes (Section 3).

NOTE.—Surface creepage and flashover at the higher voltages may be prevented by pouring around the electrodes any high-grade insulating compound which will form a good bond with the material and with the electrodes. Sealing wax and phenolic resin varnish have been successfully used under certain conditions. In applying this protective compound, care must be taken to prevent voids under the edges of the electrodes.

(*b*) For tests parallel to the laminations, the material shall be cut into sections 2 in. square. Holes shall be drilled into opposite edges of each section so as to line up with each other, the inner ends of the holes being ½ in. apart. Metal electrodes shall be used, the ends of which exactly fit the ends of the holes. Thus, in effect, the material is tested edgewise in a modified needle gap. The diameter of hole should be approximately one-fourth the thickness of the specimen. For very thin specimens it may be necessary to use a larger ratio of drill size. Results shall be expressed in total kilovolts breakdown.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1188 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 546.

32. *Number of Tests.*—For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method three tests.

New Requirements Covering Test Procedures.—Add the following new sections as Sections 33 to 35:

Tests on Both Thin and Laminated Materials at Different Temperatures

33. Where the test materials are to be used at other than room temperature, their dielectric strength characteristic should be ascertained over the operating range of temperature.

34. *Apparatus.*—Temperature control shall be obtained by the use of an air oven (or refrigerator) in the case of thin materials, or by the use of an oil bath, in the case of laminated materials.

(*a*) The air oven should be provided with some means of circulating the air, so that approximately constant temperature is maintained around the test specimen, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable. Any well-designed oven of sufficient size to hold the test equipment is satisfactory for this purpose.

(*b*) The oil bath should be provided with some means for circulating the oil, so that the temperature is substantially uniform around the test specimens, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable.

35. *Procedure.*—The test material shall be subjected to the test temperature, before voltage is applied, for a period in minutes equal to half the thickness of the specimen in mils.

The tests shall cover the operating range of temperature to which the test material is to be subjected. Where this range is considerable, tests should be made at not less than four points, so that a curve of dielectric strength (volts per mil) against temperature may be plotted. These points should include the maximum and minimum operating temperatures. The number of tests at each temperature shall be as specified in Sections 10 and 32.

Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 – 27 T):[1]

The committee recommends that these methods be revised by the addition of a procedure for the measurement of the power factor and dielectric constant of tubes, either rolled or molded; and the inclusion of an alternative substitution method for measuring the capacitance and power factor. With these revisions which are described in detail below, the committee recommends that the methods be continued as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1003 (1930); also 1930 Book of A.S.T.M. **Tentative Standards**, p. 554.

To describe the measurement of the dielectric constant and power factor of tubes, the committee recommends the following additions and changes:

Section 6.—Reletter this section as Section 6 (*a*), and change the first sentence from its present form: namely,

The dielectric constant K may be computed from the relation:

to read as follows:

(*a*) *Sheet Materials.*—For sheet materials, the dielectric constant, K, may be calculated from the following formula:

Add a new Paragraph (*b*) reading as follows:

(*b*) *Tubes.*—For materials in the form of tubes, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{3.6\, t\, (C_1 - C_2)}{D\, (l_1 - l_2)}$$

where t = the thickness of the tube in centimeters;
D = the mean diameter in centimeters;
C_1 = the measured capacitance in micro-microfarads when the electrodes have a length of l_1 centimeters; and
C_2 = the measured capacitance in micro-microfarads when the electrodes have a length of l_2 centimeters.

NOTE.—The two measurements C_1 and C_2 are made with different electrode lengths l_1 and l_2 for correction of edge effect.

If the tube thickness is so small, or the electrode length so large that the edge correction may be neglected, then the dielectric constant, K, may be calculated from the following:

$$\text{Dielectric constant, } K = \frac{3.6\, t\, C}{D\, l}$$

where C = the measured capacitance in micro-microfarads for electrodes of length l centimeters.

Section 8.—Add the following as a new Paragraph (*c*):

(*c*) *Tubes.*—For testing rolled or molded laminated tubes, the test specimen shall have the diameter and wall thickness of the material it represents, and shall be of sufficient length to provide a capacitance of not less than 100 micro-microfarads. The thickness shall be uniform to ± 5 per cent, and the surfaces shall be smooth and free from irregularities.

Section 10.—Add the following as a new Paragraph (*c*):

(*c*) *Tubes.*—The outer electrode shall consist of tin or lead foil. The inner electrode shall consist either of tin or lead foil, or of mercury. The electrodes shall completely cover the tube surfaces to within ½ in. of the ends of the specimen, shall be centered approximately with respect to the length of the specimen, and shall be located exactly opposite each other.

NOTE.—A very thin coating of petrolatum is a good adhesive for the foil. A cork or a wax plug provides means for holding the mercury in the tube.

Sections 12 to 15.—A. Substitution Method.—In the commercial operation of the Substitution Method an alternative method has been used which has been found by comparative tests in several laboratories to give the same results as the substitution method. At the present time there is no decided preference for one method over the other. The use of both methods are recommended as tentative with the hope that one will prove preferable as a standard method. Accordingly, the committee recommends that the following alternative test procedure be added as Paragraph (*b*) to Section 14 and that Section 14 be renumbered as "14. (*a*) Procedure."

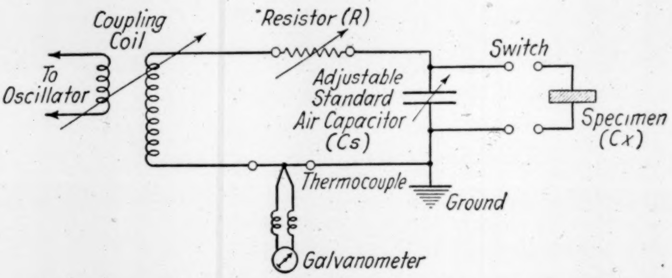

FIG. 1.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method (Alternative Procedure).

(*b*) *Alternative Procedure.*—The circuit for the alternative substitution method is shown in Fig. 7 (the accompanying Fig. 1) and consists of a coupling coil, capacitor, switch, thermocouple galvanometer, and resistors as for the Substitution Method and conforming to the requirements of Section 13.

The standard capacitor shall be tuned to resonance, first, with the specimen in parallel and then alone in the circuit. The manipulation and calculations shall be made as follows: With the resistance, R, set to zero and the specimen, C_x, in parallel with the adjustable standard air capacitator, C_s, tune C_s to resonance, read the value of C (equals C_1) and the galvanometer deflection d_1. Disconnect the specimen and tune C_s to resonance and read (equals C_2), add resistance R_1, to make galvanometer deflection equivalent to d_1, calculate C_x and R_x from the following formulas:

$$C_x = C_2 - C_1$$

$$R_x = R_1 \left(\frac{C_2}{C_x}\right)^2$$

The power factor shall be calculated from the following formula:

$$\text{Power factor} = 2\,\pi f\, C_x\, R_x$$

where f is expressed in cycles, C_x is expressed in farads, and R_x is expressed in ohms.

Figure 7.—Renumber the present figure as Fig. 8 and reletter references in the text accordingly.

Section 21.—Change the last sentence to read as follows by the addition of the italicized words and the omission of the word in brackets:

> The technique exercised in these respects shall be such that an accuracy within ± 10 per cent for the determination of power factor, [and] within ± 5 per cent for the determination of *the* dielectric constant *of sheets, and within ± 10 per cent for the determination of the dielectric constant of tubes* shall be obtained.

The committee feels that the power factor of an insulating material should be expressed as a pure number rather than as a percentage. In conformity with this it is recommended that all references to "per cent power factor" be removed from the method. This change will be handled editorially. It is to be noted that loss factor values calculated on the basis of power factor instead of power factor in per cent will be one one-hundredth as large.

Tentative Methods of Testing Laminated Sheet Insulating Materials (D 229 - 30 T):[1]

It is questionable whether the modulus of elasticity can be accurately and satisfactorily determined on a non-homogeneous material such as laminated sheet material by calculation from the measurements made to determine tensile strength. The committee believes that it is better to measure the elongation of the material under load and avoid the term modulus of elasticity. The committee accordingly recommends that these methods be revised as follows, and that the methods as revised be continued as tentative:

Section 8.—Change the first sentence to read as follows by the addition of the italicized words and the omission of those in brackets:

> 8. When it is desired to [obtain the modulus of elasticity] *determine the elongation under load*, a suitable extensometer measuring the elongation of a 2-in. gage length shall be used.

Section 9.—Change this section from its present form: namely,

> 9. Strain readings shall be taken by increments of load not exceeding about

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1216 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 590.

1000 lb. per sq. in. The modulus shall be calculated from the total change of length between zero load and stress of 5000 lb. per sq. in.

NOTE.—For some materials the stress-strain curve will not form a straight line but will be a continuous curve from the origin to the breaking load.

to read as follows:

9. The total change in length between zero load and a stress of 5000 lb. per sq. in. shall be determined.

Section 10 (f).—Change from its present form: namely,

(*f*) The modulus of elasticity, if determined.

to read as follows:

(*f*) The elongation in inches at a stress of 5000 lb. per sq. in., if determined.

Section 24.—Moisture Absorption.—It has been found that the results of this test are quite dependent on the temperature of the water. The present range of 10° C. is too great. Accordingly the committee recommends that the first sentence of Paragraph (*b*) be changed to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*b*) The dried specimen shall then be immersed in distilled water *maintained* at a temperature of [from 20 to 30° C.] *25° C. ± 2° C. (77° F. ± 3.6° F.) throughout the test.*

Tentative Methods of Test for Comparing the Thermal Conductivities of Solid Electrical Insulating Materials (D 325 – 30 T):[1]

The experience obtained with this method since its publication as tentative last year has indicated the need for some revision. The committee accordingly proposes the following changes in these methods and recommends that the methods as thus revised be continued as tentative:

Section 1.—Change the last sentence of this section to read as follows by the addition of the italicized figure and the omission of the figure in brackets:

An accuracy of [5] *10* per cent can be obtained with this method.

Section 4 (b).—Change from its present form: namely,

(*b*) *Thermocouples.*—The measuring junction or hot junction of each thermocouple shall be made of thin copper foil approximately 2.5 cm. (1.0 in.) square, to which two thermocouple wires shall be soldered, one of copper and one of a suitable alloy. The thickness of the copper foil shall be approximately 0.15 mm. (0.006 in.) and the wires shall have approximately the same diameter as the thickness of the foil. The joints between the wire and the foil shall be flattened to a thickness about the same as that of the foil. The reference junction or cold junction shall be made by soldering a copper wire to the opposite end of the alloy wire. This junction shall be mounted in a glass tube not more than 0.25 cm. (0.1 in.) in diameter which is sealed at its lower end and immersed in the ice bath so that the junction is at least 10 cm. (4 in.) below the surface.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1224 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 625.

The unconnected ends of the copper wires shall be the terminals of the thermocouple.

to read as follows:

(*b*) *Thermocouples.*—Thermocouples shall be made from wire not larger than 0.25 mm. (0.010 in.) in diameter, or No. 30, American Wire Gage, one wire being of copper and the other of a suitable alloy which will give an electromotive force of about 40 microvolts per degree Centigrade. The wire shall be provided with suitable insulation of such thickness that the over-all diameter does not exceed 0.50 mm. (0.020 in.). The junctions shall be made by soldering or welding the wires. The measuring junctions of the thermocouples, used for determining the temperatures at the surface of the specimens, shall be soldered to or embedded at, the midpoint of sheets of pure tin, or other malleable metal, which have the same shape as the contact surface of the specimens. Each sheet of tin shall not exceed 0.50 mm. (0.020 in.) in thickness, and shall be provided with a slot in which the wires leading to the junction may be laid. No part of the thermocouple or its mounting shall exceed 0.5 mm. (0.020 in.) in thickness. The reference or cold junction of each thermocouple shall be mounted in a glass tube not more than 2.5 mm. (0.1 in.) in diameter, which is sealed at its lower end and is immersed in a bath of crushed ice so that the junction is at least 100 mm. (4 in.) below the surface, and at least 25 mm. (1 in.) above the lower ice level.

NOTE.—The use of a separate reference or cold junction for each thermocouple is essential only when measurements are made on specimens of high graphite content or other materials which may be electrically conducting.

Section 5.—Change Paragraph (*b*) by deleting the second sentence which reads as follows:

The thickness of the specimen shall be measured at its midpoint with an accuracy of ± 1 per cent.

and inserting in its place the following:

Specimens should be uniform in thickness to within ± 1.5 per cent. Thickness measurements shall be made with an accuracy of 0.5 per cent at not less than ten points uniformly distributed over the surface. The average thickness shall be used for computing the thermal conductivity.

Section 7.—In Paragraph (*a*), change items (2), (6) and (10) to read as follows by the addition of the italicized words and the omission of those in brackets:

(2) [Thin] *Soft* rubber sheet;
(6) Thin, *soft* rubber sheet;
(10) [Thin sheet of rubber] *Soft rubber sheet.*

Change Paragraph (*b*) from its present form: namely,

(*b*) The pressure on the specimens shall be 25 g. per sq. cm. (50 lb. per sq. ft.).

to read as follows:

(*b*) The pressure on the specimens shall be such that doubling the pressure does not change the apparent thermal conductivity by as much as 2 per cent.

Change the note following Paragraph (*c*) from its present form: namely,

NOTE.—The thin sheet of rubber, which has a thickness of about 0.25 mm. (0.01 in.), is required to insure good thermal contact between hard surfaces. Ordinary "dental dam" is a suitable and readily obtainable sheet for this purpose. When the standard specimen and the test specimen are soft and flexible, the rubber sheet and thermocouple may be omitted.

to read as follows:

NOTE.—The soft rubber sheets called for in the above assembly are for the purpose of insuring good thermal contact at hard surfaces. Soft sheet rubber known as "dental dam" is a suitable and readily obtainable sheet for this purpose. One or more layers may be used at each surface to give the desired cushioning effect. When the specimens are soft and flexible these rubber sheets may be omitted, as may also one of the measuring junctions called for in Sections 5 and 7. Pressures of the order of 200 g. per sq. cm. (400 lb. per sq. ft.) are usually sufficient to insure good thermal contact of soft rubber specimens.

Section 8 (*a*).—Change to read as follows by the addition of the italicized words and figures:

8. (*a*) Temperature of the Plates.—The heating and the cooling plates shall be maintained at temperatures which are constant within ± 0.1° C. until the temperature differences across the specimens being compared are constant within ± 0.25° C. for one hour, *or ± 0.10° C. for 30 minutes.*

The following is the result of the latter ballot vote of the committee, which consists of 56 members, on the recommendations made in this report:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT TO STANDARD OF TENTATIVE REVISIONS OF STANDARD			
Standard Methods of Testing Electrical Insulating Oils (D 117 - 27)	33	0	17
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Methods of Testing Insulating Varnishes (D 115 - 30 T)	33	0	17
Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 30 T)	31	0	19
Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 - 27 T)	30	0	20
Tentative Methods of Testing Laminated Sheet Insulating Materials (D 229 - 30 T)	31	0	19
Tentative Methods of Test for Comparing the Thermal Conductivity of Solid Electrical Insulating Materials (D 325 - 30 T)	28	0	22

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Insulating Varnishes (F. T. Wright, chairman):

In addition to the work which Subcommittee I has done leading to the recommendations mentioned earlier in the report relative to the Tentative Methods of Testing Insulating Varnishes (D 115 – 30 T), the subcommittee has been carrying on work along other lines, which are mentioned in brief as follows:

Acid and Alkali Proof Tests.—Some study of this problem has been continued during the past year and more active work is planned for next year.

The Effect of Oven Conditions on Dielectric Strength and Time of Drying.—Impressed with the feeling that oven conditions during the baking period determine the later performance of varnish films in the tests for drying time and dielectric strength, a new section has been formed to study their effect.

Hardness and Oil Resistance of Varnish Films.—The Graham-Linton hardness tester mentioned in last year's report has been studied further with some success.

Insulation Resistance.—This property of varnish films has been given further study and work is being continued.

Subcommittee II on Molded Insulating Materials (A. M. Lynn, chairman):

Molding Compounds.—This subcommittee has devoted considerable attention to the development of tests applicable to molding compounds with the intention, first, of preparing test methods and later of writing purchase specifications for these materials. Studies are being made on tests for apparent density of molding powders, of particle size or sieve analysis, and on plasticity and cure tests.

Tolerances of Test Specimens for Impact Strength.—The investigation to determine whether the tolerances for molded test specimens now specified in the Standard Methods of Testing Molded Insulating Materials (D 48 – 30) may also be applied to the impact test specimens shown in the Tentative Methods of Testing Insulating Materials for Resistance to Impact (D 256 – 28 T) has been continued. It appears that the impact strength of specimens of different cross-sectional areas may be satisfactorily determined by dividing the energy required to break the specimen by the factor, WT^2, that is, width times thickness squared. Additional work will be necessary before including this revision in Methods D 256 – 28 T.

Type of Mold for Test Specimens.—It has been found by test that the values obtained for several of the physical tests are affected by the type of mold used in producing the test specimen. There are various types of molds in use in the industry and no fixed terminology exists to properly describe the types. It is felt that the complete elimination of the variables likely to affect the characteristics of the test specimens can probably be obtained only by specifying a complete design of mold and the molding cycle to be used. Pending more definite knowledge, the subcommittee feels that a note should be added to the methods calling attention to this fact. Accordingly the subcommittee recommends that the following note be added as an editorial revision: (1) after Section 1 of Standard Methods of Testing Molded Insulating Materials (D 48 – 30),[1] and (2) following Section 4, and also following the note in Section 5 of Tentative Methods of Testing Insulating Materials for Resistance to Impact (D 256 – 28 T):[2]

NOTE.—The type of mold used to produce test specimens has an effect on the results obtained. Cooperating laboratories should, therefore, standardize mold and testing procedure to obtain concordant results.

In view of the addition of the note mentioned above and also of the work being done on the tolerances of test specimens for impact strength, it is felt that the Tentative Methods of Testing Insulating Materials for Resistance to Impact (D 256 – 28 T), which has been published as tentative for three years, should remain in this status for at least another year.

Effect of Moisture Content on Test Specimens.—It has been shown that the moisture content of both the molding compound, from which test specimens are molded, and the specimens themselves affects the values obtained in physical tests. An investigation is being made with a view to establishing a standard procedure for molding and conditioning test specimens prior to testing in order to eliminate this variable.

Conditioning of Test Specimens for Mechanical Tests.—There is recent experimental evidence that the mechanical properties of molded compounds are appreciably affected by the amount of absorbed moisture. The subcommittee, therefore, proposes to recommend the modification of the tests for tensile strength, compressive strength, and flexural strength in the Standard Methods of Testing Molded Insulating Materials (D 48 – 30) and for impact strength in the Tentative Methods of Testing Insulating Materials for Resistance to Impact (D 256 – 28 T), when applied to molded insulating materials, by requiring that test specimens be conditioned before testing. The method of conditioning which will be recommended is as follows:

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 980.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1021 (1928); also 1930 Book of A.S.T.M. Tentative Standards, p. 598.

> The specimens shall be conditioned before testing by drying in an oven maintained at 50° C. ± 5° C. (122° F. ± 9° F.) for 48 hours, or, in the case of materials which soften at moderate temperature, by placing in a dessicator for 48 hours.

It is proposed to make this change in the methods next year.

Temperature Range during Water Absorption Tests.—Tests made by Subcommittee III led to the modification of the test for water absorption described in Tentative Methods of Testing Laminated Sheet Insulating Materials (D 229 – 30 T) by changing the specified temperature of the water in which the specimens are immersed during test from 25° C. ± 5° C. to 25° C. ± 2° C. as described elsewhere in this report. To conform with this change, Subcommittee II proposes to recommend that in the water absorption test described in Standard Methods of Testing Molded Insulating Materials (D 48 – 30), the next to the last sentence of Section 24 be modified by changing "25° C. ± 5° C." to read "25° C. ± 2° C." It is proposed to make this change in the methods next year.

Subcommittee III On Sheet Insulation (Dean Harvey, chairman):

In addition to the recommendations mentioned earlier in the report relative to the revision of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 30 T) and Tentative Methods of Testing Laminated Sheet Insulating Materials (D 229 – 30 T) which has resulted from work done by Subcommittee III, there have been several interesting studies carried on which may be briefly noted as follows:

Section 1 on Insulating Paper.—The work started last year to bring about more uniform methods of measuring thickness (within the test methods under the jurisdiction of Committee D – 9) has proceeded in close cooperation with the Technical Committee on Thickness Measurement of Committee E-1 on Methods of Testing. A method using a machinist's micrometer with careful specification of the pressure applied while measuring has been worked out and found suitable for papers. Further work is to be done to simplify the procedure and to see if the same method is applicable to other materials.

Steps taken to prepare condenser tissue specifications, has resulted in the development of a set of test methods for these tissues which are nearly in suitable form for publication as tentative.

A new testing machine has been developed for determining the edge tearing strength of untreated papers which is being tried with different grades of paper.

Arrangements have been made with the U. S. Bureau of Standards to check the Massachusetts Institute of Technology type folding endurance testers by five members of the committee as regards mechanical variables. When their report has been received the question of standardizing this type of test will be considered.

Method of test for moisture content of impregnated cable paper is in course of preparation.

Paper acidity determinations are receiving very active attention and are being studied in cooperation with committees of the Technical Association of the Pulp and Paper Industry.

Section 2 on Laminated Sheet Insulating Materials.—Cooperation has continued between this group and the Technical Committee of the Laminated Products Section of the National Electrical Manufacturers Association. A compressibility test, originating at the Bell Telephone Laboratories, is being studied; arc-resistance tests are receiving attention, and methods of determining impact strength and of studying impact fatigue of laminated materials are being worked on. Laminated rods and tubes which demand test treatment slightly different from that applying to laminated sheet materials have received attention and test methods worked out in considerable detail.

Section 3 on Deterioration of Sheet Insulating Materials.—The tests developed by this section to measure the effect of heat on the properties of paper are to be written up as a tentative standard.

Section 6 on Varnished Cloth and Tubing.—This section is still working on test methods and specifications for flexible varnished tubing and expects to have them completed shortly. Work is being started on material specifications for varnished cloth and varnished cloth tapes.

Subcommittee IV on Liquid Insulation (E. A. Snyder, chairman):

In addition to recommending the changes in the Standard Methods of Testing Electrical Insulating Oils (D 117 - 27) given earlier in this report, this subcommittee has continued actively the study of a number of problems on transformer and circuit breaker oils. Some of the more important of these are as follows:

Neutralization Number.—Subcommittee IV during the year continued the study of electrometric titration methods for determining neutralization number of oils referred to in the 1930 report,[1] and the subcommittee now feels that two methods have been developed which can be used with a fair degree of accuracy and with fair agreement with the colorimetric titration method described in the Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 27 T).[1] One of these methods is the method developed by B. L. Clark of the Bell Telephone Laboratories. (Note that the 1930 report,[2] through an error, credited this method to F. M. Clark instead of B. L. Clark.) It was agreed that, although the subcommittee did not feel that either method was sufficiently developed to recommend it as a tentative standard, it was nevertheless desirable to have available for those interested in this method a detailed description of the two methods which the subcommittee, through extensive work, has found to be the most accurate.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 841 (1930).

The subcommittee has in the past three years' work experimented with practically every recommended electrotitration method and it was thought desirable to have on record a description of the two methods which have given most promise of being standardized, in order that subsequent work of this or any other subcommittees along these lines would not necessitate the same long process of elimination by trial and study. A description of the two methods and a short description of the results obtained by their use appears in the report of the section appended to this report.

Sludge Tests.—A suitable method for determining the sludging characteristics of insulating oils is still one of the chief subjects of investigation by Subcommittee IV. Considerable progress has been made in the investigation of the nine research problems listed in the 1930 report[3] under this heading, and although the work has not been completed, the general conclusions derived from this investigation to date are as follows:

1. The oil receptacle, using the life test oven, should be heated from the bottom to secure the maximum oxidation at a given temperature;
2. The oil depth to surface ratio, while it should be standardized, is not of major importance in sludge testing as outlined.
3. There is no abnormality indicating an abrupt change in the mechanism of sludge formation between 110 and 130° C.
4. There is no definite factor that can be established between sludge results expressed by volume and weight.
5. The speed of centrifuging is of real importance in determining sludge life and sludge accumulation in its early stages.
6. Sludge accumulation results by volume should be determined between 0.5 and 1 per cent. Over this range the time of centrifuging

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 927 (1927); also 1930 Book of A.S.T.M. Tentative Standards, p. 378.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 841.

[3] *Ibid.*, p. 842.

at 1500 r.p.m. is not of importance beyond 80 minutes. A speed of 4500 r.p.m. for 20 minutes, which gives results equivalent to those obtained for 80 minutes at 1500 r.p.m., is to be preferred for volume tests because of the closer sludge packing obtained.

7. Expression of sludge values by weight appears to be preferred over volumetric determinations.

Short-Time Sludge Tests.—The development of a short-time sludge test to be used in controlling the uniformity of shipments of one type of oil which has been approved as a satisfactory insulating medium for a definite purpose, but which is not intended to be used as an acceptance test method for all types of insulating oils, has been making steady progress during the year, and while a number of methods have been tried and studied, it now appears that the Sligh test, with suitable modifications, may be the recommended procedure. Although it had been hoped to have this method in suitable form for publication as tentative this year, it was found impossible to complete all the preparatory investigations necessary and the tentative method will therefore not appear until during the coming year.

Moisture in Insulating Oils.—Progress has been made by this new section of Subcommittee IV as referred to in the 1930 report. Several methods have been tried and discussed. The ordinary methods employed for moisture determination have been considered unsatisfactory, chiefly because they are incapable of differentiating between moisture and oxidation products. The method involving the use of a high-speed centrifuge (6000 r.p.m.) is now being studied. A modification has been suggested that involves the electrical activation of the sample to be tested during centrifuging.

In addition to the above, the subcommittee has been actively engaged in studying and developing special tests for circuit breaker oils and methods for determining saponification number of insulating oils.

Subcommittee VII on Electrical Tests (E. S. Lee, chairman):

This subcommittee has been formed since the last annual report through the consolidation of the former Subcommittees VII on Radio Frequency Tests and VIII on Resistance and Power Factor Measurements. In addition to the revisions being recommended as mentioned earlier in the report, affecting the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (D 150 – 27 T) and the Tentative Method of Test for Comparing the Thermal Conductivities of Solid Electrical Insulating Materials (D 325 – 30 T), the subcommittee has been working along the following lines:

Section A on Resistivity is working on electrodes for resistivity tests on sheet insulation.

Section B on Power Factor of Liquid Insulation and Section C on Power Factor of Solid Insulation are working jointly on a method of measuring power factor at 60 cycles. Section C expects to have very shortly a method for measuring power factor at 1000 cycles. This section is interested in progress of work in measuring power factor at very high frequencies, such as 20 megacycles; also in methods of checking power factor measuring equipment.

This report has been submitted to letter ballot of the committee, which consists of 56 members; 50 members returned their ballots, of whom 47 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

H. L. CURTIS,
Chairman.

J. A. SCOTT,
Secretary.

EDITORIAL NOTE

The tentative revision of the Standard Methods of Testing Electrical Insulating Oils was approved at the annual meeting and subsequently adopted as standard by letter ballot vote of the Society on September 1, 1931. The methods in their revised form appear in the 1931 Supplement to Book of A.S.T.M. Standards, p. 104.

The proposed revisions of the Tentative Methods of Testing Insulating Varnishes, Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength, Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles, Methods of Testing Laminated Sheet Insulating Materials and Methods of Test for Comparing the Thermal Conductivities of Solid Electrical Insulating Materials were accepted. The methods in their revised form appear on pages 848, 867, 877, 889, and 897, respectively.

REPORT OF SECTION A, OF SUBCOMMITTEE IV, ON NEUTRALIZATION METHODS FOR ELECTRICAL INSULATING OILS

The several cooperating laboratories carrying on the work of this section, found a fair agreement between the neutralization numbers as determined by the colorimetric titration method described in the Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 27 T)[1] and the electrometric methods used in this cooperative work. The electrometric methods include one method formulated by this section and entitled "Method A" in this report; the other, independently developed by B. L. Clark of the Bell Telephone Laboratories, entitled "Method B" in this report.

TABLE I.—DESCRIPTION OF SAMPLES USED IN COOPERATIVE TESTS.

Sample	Description	Color	Approximate Viscosity at 100° F., seconds
No. 1.....	Used transformer oil..........	Red	93
No. 2.....	Spindle oil sludged in Funk sludging machine (water removed centrifugally)....	Pale	76
No. 3.....	Turbine lubricating oil sludged in Funk sludging machine (water removed centrifugally)..........	Pale	147
No. 4.....	Used turbine lubricating oil blended with equal volume of used transformer oil ...	Red	142
No. 5.....	Used crankcase oil..........	Red	378
No. 6.....	Used turbine lubricating oil blended with 85 per cent by volume of a heavy cylinder stock..........	Pale	416

These methods are published for the information of the members of the Society and others in order that there may be more tests carried out, more experience gained, and more opportunity to explore the difficult field of the determination of the neutralization value and its meaning, particularly as applied to dark colored new oils and to used oils whether dark in color or not.

Six samples were submitted for cooperative tests as described in Table I. Two laboratories have submitted results by both the electrometric and colorimetric methods, the latter carried out in accordance with the A.S.T.M. Tentative Method D 188 - 27 T. One laboratory submitted results by the electrometric method only and two by the colorimetric method only. The results obtained by the various laboratories are given in Table II.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 927 (1927); also 1930 Book of A.S.T.M. Tentative Standards, p. 378.

In spite of the apparent agreement shown in Table II, it is not felt that the electrometric method is as yet suitable for recommendation to the Society for publication as a tentative method of test fo routine work or even for research work.

TABLE II.—TEST RESULTS FOR NEUTRALIZATION NUMBER, VALUES EXPRESSED IN MILLIGRAMS OF KOH PER GRAM OF OIL.

Sample	Electrometric Methods			Colorimetric Method (A.S.T.M. Method D 188 - 27 T)			
	Laboratory			Laboratory			
	No. 1[a]	No. 2[a]	No. 3[b]	No. 1	No. 2	No. 4	No. 5
No. 1...	1.59 1.59 1.59 Ave.	1.61 1.61 1.61 Ave.	1.559	1.52	1 52	1.40	1.45
No. 2...	0.265 ..... 0.265 0.265 Ave.	0.26 0.23 0.25 0.25 Ave.	0.274	0.285	0.26	0.35	0.322
No. 3...	0.018 0.019 0.019 Ave.	0.02 0.02 0.02 Ave.	0.031	0.025	0.06	0.04	0.042
No. 4...	0.804 ..... 0.835 0.819 Ave.	0.88 0.92 0.91 0.90 Ave.	0.807	0.825	0.77	0.75	0.812
No. 5...	0.194 0.195 0.195 Ave.	0.14 0.13 0.14 Ave.	0.162	0.190	0.13	0.20	0.196
No. 6...	0.183 0.194 0.188 Ave.	0.17 0.17 0 17 Ave.	0.182	0.206	0.15	0.25	0.252

[a] Tests carried out by Method A.
[b] Tests carried out by Method B.

ELECTROMETRIC METHODS FOR DETERMINATION OF NEUTRALIZATION NUMBER OF MINERAL INSULATING OILS

METHOD A

1. *Apparatus.*—The apparatus shall consist of the following:

(*a*) *Electrodes.*—One bright platinum electrode, approximately 1 cm. square, 0.15 mm. in thickness, sealed into glass tubing. Connection to copper wires shall be made by means of mercury.

One silver chloride electrode, prepared as follows:

A piece of silver foil 10 mm. in width and 30 mm. in length shall be fastened to a short piece of platinum wire which may then be sealed into one end of a piece of glass tubing. Chemically pure silver chloride shall be heated and melted in a crucible until it is cherry red. The silver foil on the tubing shall then be immersed in the molten silver chloride, withdrawn, and allowed to cool. After an electrode has been used for a few days it should be cleaned by immersing in concentrated ammonium hydroxide solution and then washed. The cleaned piece of silver foil shall be recoated with silver chloride as just described.

(*b*) *Burette.*—Burette with 0.1-cc. graduations.

(*c*) *Titration Cell.*—A 250-cc. wide-mouth bottle with a 5-hole, tight cork stopper to fit.

(*d*) *Galvanometer.*—Galvanometer of suitable sensitivity. A portable galvanometer having the following characteristics will be found suitable: sensitivity, 0.025 microampere per millimeter; period, 3 seconds; external critical damping resistance open circuit; resistance, 1060 ohms.

(*e*) *Potentiometer.*—A potentiometer with a range of 0 to 1.6 volts.

2. *Solutions and Reagents Required.*—The following solutions and reagents will be required:

(*a*) *Normal Butyl Alcohol.*—Normal butyl alcohol containing 20 g. lithium chloride per liter.

NOTE.—The normal butyl alcohol used in the preparation of the potassium hydroxide solution must be free from aldehyde. This may be secured by treating it with silver nitrate in an alkaline solution, and it should then be freed from water by refluxing with quicklime, followed by distillation in an atmosphere of nitrogen.

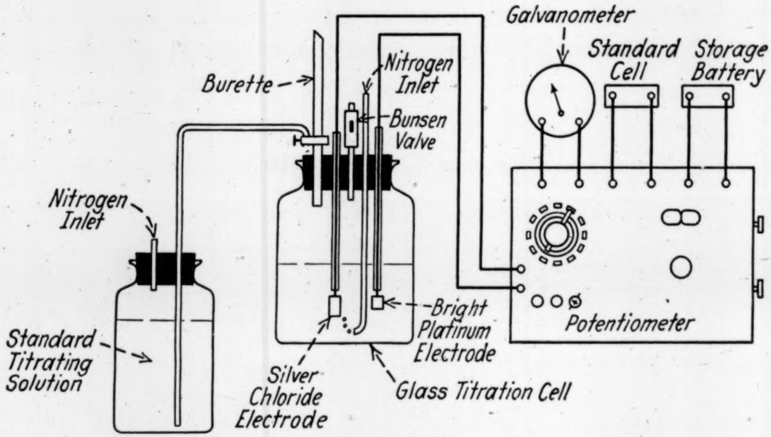

FIG. 1.—Electrometric Titration Apparatus Using Silver Chloride Electrode.

(*b*) *Potassium Hydroxide Solution.*—Solution of 0.05 *N* KOH in normal butyl alcohol, standardized against U. S. Bureau of Standards' benzoic acid.

NOTE.—The standard solution of potassium hydroxide in normal butyl alcohol shall be stored under nitrogen in a dark bottle to prevent deterioration.

(*c*) *Quinhydrone.*

(*d*) *Nitrogen.*—A cylinder of nitrogen.

3. *Procedure.*—The glass titration cell shall be set up as shown in Fig. 1. A sample of oil weighing between 2 to 10 g. (Note 1) shall be accurately weighed and placed in the titration cell. One hundred cubic centimeters of normal butyl alcohol containing the lithium chloride and 0.04 g. of quinhydrone (Note 2) shall then be added, the cell stoppered, and the contents mixed by bubbling nitrogen through it. The voltage of the titration cell shall be measured and, after this voltage has become constant, standard alkali shall be added in small increments and the voltage determined after the addition of each increment. The size of the increment of alkali added may be 0.5 cc. in the early stages of the titration but shall be reduced to 0.2 cc. or less as the end point is approached.

The approach of the end point can be noted by the rate of change of voltage per cubic centimeter of alkali. Nitrogen shall be bubbled through the cell during the titration at a sufficiently rapid rate to keep the contents stirred. Mixing may be accelerated by shaking the cell by hand after each addition of alkali.

A blank titration shall be made on the solvent.

NOTE 1.—The size of sample to be used in the titration should be adjusted in accordance with the nature of the oil. For a highly-acid, used oil 2 to 3 g. is sufficient, for a new oil or one of low neutralization value, 10 g. of sample may be needed.

NOTE 2.—The quinhydrone should be added to the solvent just prior to titration since quinhydrone tends to deteriorate if kept in the solvent for a prolonged period of time.

4. *Calculation.*—The neutralization number shall be determined by plotting $\frac{\Delta \text{ e.m.f.}}{\Delta \text{ cubic centimeters of alkali}}$ against total cubic centimeters of alkali added. The peak in this curve represents the end point. The neutralization number in milligrams KOH per gram of oil shall also be calculated from the following formula:

$$\text{Neutralization number} = \frac{\left(\begin{array}{l}\text{cubic centimeters of alkali} - \\ \text{cubic centimeters of blank}\end{array}\right) \times \begin{array}{l}\text{milligrams KOH per} \\ \text{cubic centimeter of} \\ \text{standard alkali}\end{array}}{\text{weight of sample in grams}}$$

METHOD B

5. *Apparatus.*—The apparatus shall consist of the following:

(*a*) *Thermionic Titrometer.*—The thermionic titrometer consists of a vacuum tube circuit shown in Fig. 2.

(*b*) *Titration Cell.*—A 250-cc. Erlenmeyer flask with a 5-hole stopper to fit.

(*c*) *Electrode.*—A bright platinum electrode sealed in glass tubing.

(*d*) *Burette.*—A burette with a two-way stopcock.

(*e*) *Tubes.*—A soda lime tube and a mercury sealing tube

(*f*) *Calomel Cell.*—A saturated calomel half cell.

(*g*) *Agar-Agar Salt Bridge.*—The agar-agar salt bridge consists of a tube 15 cm. in length and 6 mm. in diameter with one end drawn to a capillary. The tube shall be half-filled with a hot agar solution prepared by dissolving 1.2 g. or agar and 2.0 g. of lithium chloride in 100 cc. of boiling distilled water. After half-filling the tube with the hot agar solution and cooling, the remaining half of the tube shall be filled with a saturated potassium chloride solution.

6. *Solutions and Reagents.*—The following solutions and reagents will be required:

(*a*) *Normal Butyl Alcohol.*—Normal butyl alcohol.

NOTE.—The normal butyl alcohol used in the preparation of the potassium hydroxide solution must be freed from aldehyde by treatment with silver nitrate in alkaline solution, and from water by refluxing with quicklime followed by distillation in an atmosphere of nitrogen.

(*b*) *Potassium Hydroxide Solution.*—Solution of 0.05 *N* KOH in normal butyl alcohol, standardized against U. S. Bureau of Standards' benzoic acid.

NOTE.—The solution of potassium hydroxide must be kept in a light-proof bottle protected from air by soda lime and alkaline pyrogallol towers. The bottle containing the alkaline solution must be connected directly to the burette to avoid exposure to air during filling. The alkaline solution shall be standardized against Bureau of Standards' benzoic acid in the manner described in Section 7 for titration of oils, substituting the benzoic acid for the oil sample.

(*c*) *Saturated Solution of Lithium Chloride in Normal Butyl Alcohol.*—The saturated solution of lithium chloride in butyl alcohol shall be prepared by refluxing an excess of the salt with the alcohol for several hours. The saturated solution must be stored in a light-proof bottle.

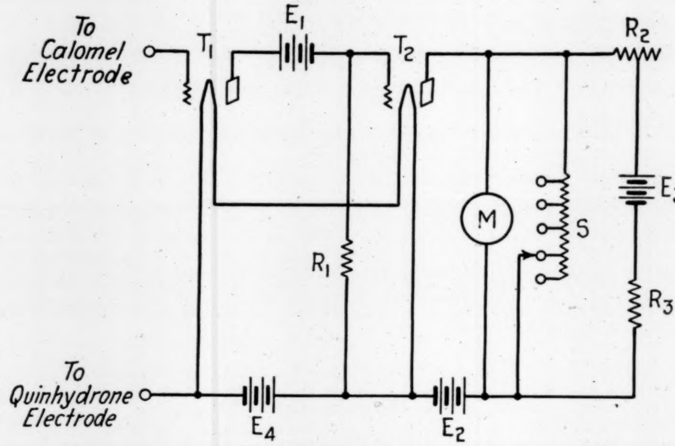

FIG. 2.—Thermionic Titrometer.

T_1 = Vacuum Tube No. 102-G, Western Electric
T_2 = Vacuum Tube, No. 101-D, Western Electric
E_1 = 135-volt battery (radio dry-cell, "B" battery)
E_2 = 135-volt battery (radio dry-cell, "B" battery)
E_3 = 18-volt battery (radio dry-cell, "B" battery)
E_4 = 6-volt battery (lead accumulator)
R_1 = 15,000 ohm fixed resistor
R_2 = 0 to 10,000 ohm variable resistors (in steps of 0.1 ohm)
R_3 = 1000 ohm fixed resistors
S = Shunt for the meters, adjustable so that full scale deflections correspond to currents of 0.1, 1, 10, and 100 milliamperes respectively
M = Direct current milliammeter
All resistors, tap switches, and connections must be well made

(*d*) *Quinhydrone.*

(*e*) *Nitrogen.*—A cylinder of nitrogen.

(*f*) *Agar-agar.*

Unless otherwise stated, all reagents shall be of c.p. quality.

7. *Procedure.*—The apparatus shall be assembled as shown in Fig. 3. A sample of oil weighing about 10 g. shall be accurately weighed and placed in the 250-cc. Erlenmeyer flask. A 10-cc. portion of the saturated lithium chloride-butyl alcohol solution shall then be diluted to 110 cc. with the pure normal butyl alcohol and approximately 50 mg. of quinhydrone dissolved in it. This solution shall then be added to the oil in the Erlenmeyer flask and the contents shaken until solution is complete. The titration cell shall then be placed in position (see Fig. 3) and a stream of nitrogen allowed to bubble through the solution for 10 minutes.

The thermionic titrometer shall be adjusted as follows (see Fig. 2): The meter, M, must be shunted by means of the lowest resistance shunt at S, and the various batteries connected. The electrodes shall then be placed in the circuit and R_2 adjusted while progressively changing the shunt until the meter reads zero on the most sensitive scale.

NOTE.—In case erratic fluctuations of the meter needle are encountered during adjustment of the titrometer for a titration, it is necessary to short-circuit the meter, disconnect the electrodes, and connect the terminals of the instrument together. If the trouble disappears when the meter is again set at zero on the most sensitive scale, the trouble must have been in the electrodes. If the trouble remains, it must be due either to faulty connections in some part of the circuit or to faulty batteries.

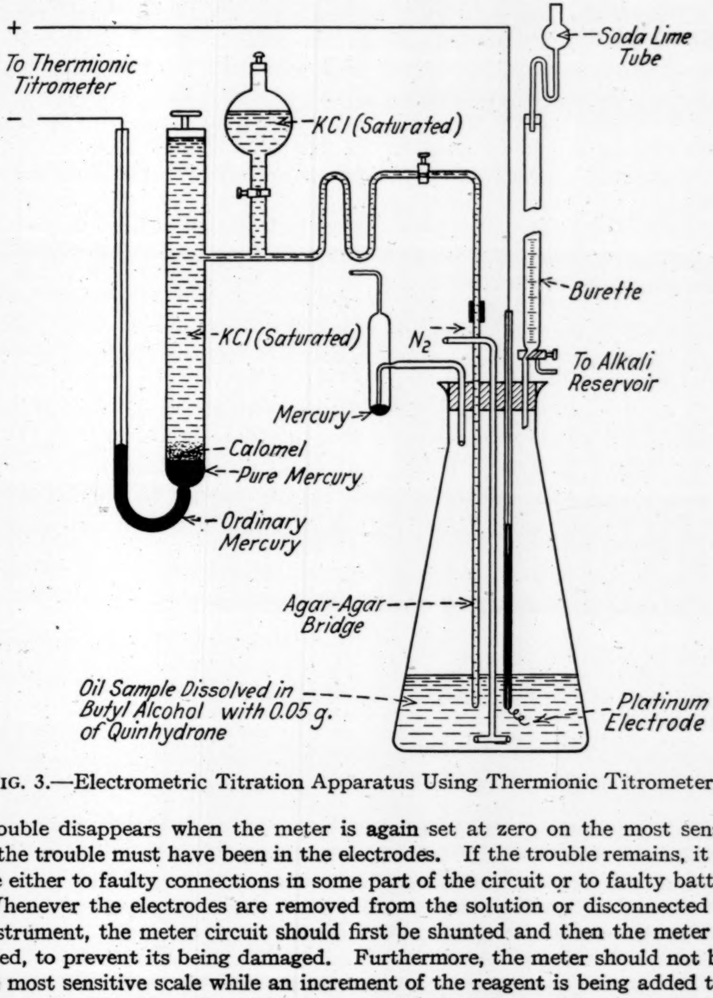
+
To Thermionic Titrometer
–
Soda Lime Tube
KCl (Saturated)
Burette
KCl (Saturated)
N_2
To Alkali Reservoir
Mercury
Calomel
Pure Mercury
Ordinary Mercury
Agar-Agar Bridge
Oil Sample Dissolved in Butyl Alcohol with 0.05 g. of Quinhydrone
Platinum Electrode

FIG. 3.—Electrometric Titration Apparatus Using Thermionic Titrometer.

Whenever the electrodes are removed from the solution or disconnected from the instrument, the meter circuit should first be shunted and then the meter open circuited, to prevent its being damaged. Furthermore, the meter should not be set on the most sensitive scale while an increment of the reagent is being added to the solution in the titration cell. If the instrument is in daily use, the batteries should be left permanently connected to avoid delays while waiting for the circuit to reach a steady state.

With R_2 adjusted as above stated, set the meter shunt for the next higher scale reading. Add from the burette exactly 0.5 cc. of the KOH solution in butyl alcohol. Record the equilibrium deflection of the meter needle in milliamperes and then adjust R_2 until meter M again reads zero. Read the burette, and add a second 0:5-cc. portion of the reagent, recording the deflection as before. Proceed in this manner until a maximum deflection has been passed. This will constitute a rough titration to locate the region in which the maximum occurs. Repeat the titration using a fresh sample of proportionate weight but running the reagent into the solution until within about 0.5 cc. of the burette reading at which the maximum should occur, as indicated in the rough titration. When this point has been reached, add the reagent dropwise in *equal* increments of approximately 0.1 cc., carrying the titration well beyond the maximum.

Blank titrations on the solvent must be made daily (preferably both before and after testing the oil samples) in the manner described above except that the oil is omitted. All titrations must be corrected by subtracting the value of the blank.

8. *Calculation.*—The volume of the reagent plotted against the deflection of the meter in milliamperes will give curves showing peaks of the equivalence (end) points of the titrations.

CONCLUSIONS

A considerable amount of further research work should be done on this subject, including the determination of the initial potential with standard electrodes such as the calomel electrode and the polished platinum electrode in the quin-hydrone solution without titration with alkali. In addition, these results should be correlated with the results of corrosion tests, galvanic potentials, and extent of oxidation.

Respectfully submitted on behalf of the section,

A. E. FLOWERS,
Chairman.

REPORT OF COMMITTEE D-11
ON
RUBBER PRODUCTS

Committee D-11 on Rubber Products held one meeting during the year in addition to the meeting held during the 1930 annual meeting. This was at Pittsburgh, Pa., March 18, 1931, at the time of the Spring Group Meeting of A.S.T.M. Committees. No fall meeting was held as the work of the committee was progressing by correspondence and as the rubber industry was especially affected by the generally adverse business conditions.

Subsequent to the 1930 report, the committee recommended revisions of two tentative standards under its jurisdiction, namely, the Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 28 T) and Tentative Method of Test for Hardness of Soft Rubber (In Slab Form) (D 314 – 29 T). The committee referred these revisions to Committee E-10 on Standards for publication as tentative.[1] The revisions as recommended by the committee were approved by Committee E-10 on August 12, 1930. The revision in the Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296–28 T) provided for increasing the specified maximum organic acetone extract in the rubber lining from 3 per cent to 4 per cent to permit the use of organic accelerators and antioxidants. The revision in the Tentative Method of Test for Hardness of Soft Rubber (In Slab Form) (D 314 – 29 T) included a change in the title to read "Tentative Method of Test for Hardness of Rubber." The method was also completely rewritten so as to be more easily understood and the load actuating the penetrating element was specified as dead weight.

The committee has decided to reconsider the recommendation made in the annual report for 1930 that the Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 – 28) be submitted to the American Standards Association for approval as American Tentative Standard. The reason for this action is that numerous objections have since been advanced concerning these specifications in their present form and a section of Subcommittee IX on Insulating Tape has been authorized for the purpose of making a general review of the specifications in order to bring them up to date and in agreement with best modern practice.

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[1] In submitting the revisions to Committee E-10 the committee reported the following results of the letter ballot vote from a total of 35 ballots returned: Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 28 T), 28 affirmative, none negative with 7 members not voting; Tentative Method of Test for Hardness of Soft Rubber (In Slab Form) (D 314 – 29 T), 29 affirmative, none negative with 6 members not voting.

Representation of Committee D-11 on other committees of the Society has been provided by the following appointments:

Mr. C. H. Zieme, Representative on Committee E-1 on Methods of Testing;

Mr. C. B. Martin, Representative on Sectional Committee on Insulated Wires and Cables;

Mr. D. C. Scott, Representative on General Membership Committee.

A new subcommittee was authorized at the last annual meeting following the final report of Subcommittee XVI on Flexing Tests on Rubber Products. The latter subcommittee was originally organized to investigate the flexing machine now made by the Henry L. Scott Co. with reference particularly to its suitability as a performance test machine for specification work. The findings of the committee as already fully presented in progress reports were that the machine is very valuable for development work on product when operated under proper conditions by men skilled in handling it but that it is not suitable at the present time for use by purchasers of materials on specifications. In discharging Subcommittee XVI at its own request, the committee felt that the valuable work which has been done by this subcommittee should be extended in a broader field. To this end, Subcommittee XVIII on Dynamic Fatigue Testing for Rubber Products was created to study the more general field indicated in its name as applied particularly to repeated extension, bending and similar tests. Mr. W. L. Sturtevant was appointed chairman of the new subcommittee.

There have been two changes during the year in subcommittee chairmen due to resignations. Mr. E. G. Kimmich was appointed chairman of Subcommittee I on Mechanical Rubber Hose, replacing Mr. H. E. Morse. Mr. R. A. Schatzel replaced Mr. Stanley Krall as Chairman of Subcommittee XV on Life Tests for Rubber Products. The committee wishes to record its appreciation of the service rendered by the retiring subcommittee chairmen. Ten members have been added to the committee and seven have retired leaving a net gain of three members.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item. Comments, where necessary, are made under Subcommittee Activities.

Proposed Tentative Standard.—The committee recommends for publication as tentative the proposed Tentative Specifications for Rubber Pump Valves, appended hereto,[1] to supersede the present Standard Specifications for Rubber Pump Valves (D 151 - 23) which are recommended to be withdrawn. The reason for this action is that the present specifications have been used by very few purchasers and have been subjected to numerous criticisms. The proposed specifications are in general agreement with the Master Specifications for Rubber Valves of the Federal Specifications Board of the U. S. Department of Commerce, and with those to be issued by the Rubber Manufacturers Association.

Proposed Revision of Standard.—The committee recommends for publication as a tentative revision, changes, as given in the Appendix, in the Standard Methods of Testing Rubber Products (D 15 - 24).[2] The reason for these revisions is to bring the methods more in accord with commonly accepted practice and to make them more generally applicable.

Proposed Revision of Tentative Standards.—The committee proposes revisions, as given in the Appendix, in the following two tentative specifications and one tentative method and recommends that the tentative standards as revised be continued as tentative:

Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 - 28 T);[3]

Tentative Specifications for Steam Hose (D 54 - 24 T);[4] and

Tentative Methods of Chemical Analysis of Rubber Products (D 297 - 29 T).[5]

The revisions recommended in the Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 - 28 T) make them more complete by adding new sections not previously included on lead sheaths and on single and double braids. Changes in Part B on Insulation permit the use of antioxidants and organic accelerators which is in accord with advance in the art. A change in thickness of insulation on No. 8 wire is included as this is considered desirable by most manufacturers and consumers. Limitation of the time of testing has been added to prevent disagreement in specified test values due to various degrees of aging of the rubber material.

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[1] See p. 944.—ED.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1033 (1928); also, 1930 Book of A.S.T.M. Tentative Standards, p. 652.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 1059 (1924); also, 1930 Book of A.S.T.M. Tentative Standards, p. 648.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 795 (1929); also, 1930 Book of A.S.T.M. Tentative Standards, p. 673.

The revisions in the Tentative Specifications for Steam Hose (D 54 – 24 T) are recommended in the interest of standardization to bring them more nearly in agreement with similar specifications issued by the Federal Specifications Board and the American Railway Association. Certain of the revisions, as mentioned in the Appendix, represent an improvement in quality.

The revisions in the Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 29 T) take into account the use of organic accelerators and antioxidants as adopted in modern rubber compounding practice. Organic acetone extract check allowances are widened slightly to limits more suitable for commercial work.

The above recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. PROPOSED TENTATIVE STANDARD			
Tentative Specifications for Rubber Pump Valves	29	2	9
II. PROPOSED TENTATIVE REVISION OF STANDARD			
Standard Methods of Testing Rubber Products (D 15 – 24)	30	0	3
III. PROPOSED REVISION OF TENTATIVE STANDARDS			
Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 – 28 T)	25	1	7
Tentative Specifications for Steam Hose (D 54 – 24 T)	20	0	13
Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 29 T)	31	0	2
IV. WITHDRAWAL OF STANDARD			
Standard Specifications for Rubber Pump Valves (D 151 – 23)	32	1	7

SUBCOMMITTEE ACTIVITIES

Subcommittee I on Mechanical Rubber Hose (E. G. Kimmich, chairman).—This subcommittee is recommending revisions in the Tentative Specifications for Steam Hose (D 54 – 24 T). The subcommittee has voted to proceed with the preparation of specifications covering the general methods for testing the various kinds of wrapped and braided hose. A section consisting of Messrs. E. G. Kimmich, C. H. Zieme, W. L. Sturtevant and E. E. Chapman has been organized to prepare these methods.

Subcommittee II on Belting (C. H. Zieme, chairman).—A new specification covering methods of test of rubber belting for power transmission was approved at the meeting of the committee held during the annual meeting, subject to letter ballot. Prior to the letter ballot, it developed that additional changes were necessary in the specification which was therefore referred back to the subcommittee. Further work is in progress correlating this standard with that being prepared by the Rubber Manufacturers Association and it is now expected that the new standard will be ready shortly. The subcommittee had definitely decided not to include the flexing test in belting specifications.

Subcommittee IV on Protection of Persons from Electric Shock (H. S. Vassar, chairman).—During the year the work of this subcommittee on electrician's gloves has consisted mainly in cooperating with the National Electric Light Association in their compilation of extensive data on gloves and their life in service. The present Standard Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits Not Exceeding 3000 Volts to Ground (D 120 – 23) have been adopted by the National Electric Light Association and by the Federal Specifications Board and are continually being more widely used. As a new project for the consideration of the subcommittee, the question of the advisability of preparing standard specifications for linemen's blankets has been suggested.

Subcommittee V on Insulated Wire and Cable (C. B. Martin, chairman).—This subcommittee has been very active during the year and the results of this work are being presented in the form of revisions to the Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 – 28 T) as given in the Appendix. These revisions include the adding of sections on Lead Sheaths for Rubber Insulated Cables, on Single and Double Braids for Covering Rubber Insulated Wires and Cables, and revisions of Part B on Insulation to permit the use of antioxidants and organic accelerators in the rubber insulating compounds. Other revisions recommended in these tentative specifications provide for an increase in the thickness of insulation on No. 8 wire and change the time of testing so that it shall be done not earlier than 24 hours nor later than 60 days after vulcanization.

The Performance Specification Section is continuing its work on the tentative performance specification which has been under consideration and expects to complete this soon.

A Section on Braids consisting of Messrs. R. J. Long, Jr., R. A. Schatzel and C. R. Troop has been organized to study this subject further and to handle any comments received.

A section to confer with representatives of the National Electric Manufacturers Association in connection with specifications under consideration by both organizations was authorized and consists of Messrs. F. M. Waring, J. H. Ingmanson, and C. R. Troop.

Investigation is being made looking toward modification of the requirement in the Tentative Specifications for Insulated Wire and Cable (D 27 – 28 T) that all copper wires to be insulated shall be "properly tinned," so as to permit the use of other coatings equal to or superior to tin for this purpose.

Subcommittee VI on Packings, Gaskets and Pump Valves (W. L. Sturtevant, chairman).—This subcommittee has prepared new Proposed Tentative Specifications for Rubber Pump Valves, as appended hereto,[1] which are being recommended to supersede the present Standard Specifications for Rubber Pump Valves (D 151 – 23).

Subcommittee IX on Insulating Tape (J. M. Bierer, chairman).—This subcommittee received a request from a manufacturer that the desirability of developing standards for a combination friction and rubber tape be investigated. The committee decided that this material is as yet highly specialized and a product of the particular manufacturer and not in sufficient demand to warrant preparation of specifications at this time.

Subcommittee X on Standard Procedure for Testing Rubber Products (A. W. Carpenter, chairman).—This subcommittee is sponsoring revisions in the Standard Methods of Testing Rubber Products (D 15 – 24) as given in the Appendix to this report. These revisions are intended to elicit comment and criticism and will be used in a complete revision of the Methods for Physical Testing which is to be prepared by a section of the subcommittee consisting of Messrs. A. W. Carpenter, *ex-officio*, E. G. Kimmich, F. D. Abbott, and C. H. Zieme. The ultimate intention is to withdraw the present Standard Methods D 15 – 24 and replace it with two standards, one on chemical analysis and the other on physical tests.

It has been decided to change the name of this subcommittee to "On Physical Testing of Rubber Products." A section has been authorized on performance tests with instructions to proceed first to assemble information on testing of V-belts.

Subcommittee XI on Chemical Analysis of Rubber Products (S. Collier, chairman).—This subcommittee has prepared revisions to the Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 29 T) as given in the Appendix, which are designed to take into account the effect of organic accelerators and antioxidants on acetone extract determination. The organic acetone extract check allowances are also being increased slightly. The subcommittee points out that in individual specifications for rubber goods in which limits are placed on the organic acetone extract, consideration should be taken of the permissible use of organic accelerators and antioxidants.

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[1] See p. 944—ED.

Subcommittee XIV on Abrasion Tests for Rubber Products (H. A. Depew, chairman).—A Symposium on Abrasion Testing of Rubber and the related tests of tearing and cutting has been arranged by this subcommittee for the annual meeting.[1] Five papers will be presented in this symposium and will be followed by an open discussion on the general subject of abrasion testing.

Subcommittee XVII on Rubber Products for Absorbing Vibration (F. D. Abbott, chairman).—The Section on Hardness of this subcommittee has prepared and submitted a revision as mentioned earlier in the report of the Tentative Method of Test for Hardness of Soft Rubber (In Slab Form) (D 314 – 29 T) which was accepted by Committee E-10 on Standards at its meeting on February 20, 1931.

The Section on Flow Testing has accumulated information on the types of equipment in use and is working with the manufacturers of testing equipment with a view toward developing standard apparatus.

This report has been submitted to letter ballot of the committee, which consists of 65 members; 33 members returned their ballots all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. B. WIEGAND,
Chairman.

A. W. CARPENTER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Rubber Pump Valves, to replace the Standard Specifications for Rubber Pump Valves, were accepted for publication as tentative and appear on page 944. The withdrawal of the standard specifications was approved.

The proposed revision of the Standard Methods of Testing Rubber Products was accepted for publication as tentative and appears on page 1067.

The proposed revisions of the Tentative Specifications for Steam Hose and Methods of Chemical Analysis of Rubber Products were accepted. The specifications and methods in their revised form appear on pages 921 and 947, respectively.

The proposed revisions of the Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber, as revised on the floor of the annual meeting, see Summary of Proceedings, page 22, were accepted. The specifications in their revised form appear on page 926.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 31, Part II, p. 895 (1931).

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR RUBBER PRODUCTS

In this Appendix are given proposed revisions in certain standards and tentative standards. In connection with each title is given the reference to the publication in which the standards appear in their present form.

PROPOSED TENTATIVE REVISION OF STANDARD

Standard Methods of Testing Rubber Products (D 15 – 24):[1]

Sections 1 to 47.—A tentative revision of these standard methods in the form of separate Tentative Methods of Chemical Analysis of Rubber Products (D 297 – 29 T),[2] intended to replace when adopted Sections 1 to 47 of the present methods, is recommended to be revised in accordance with the revisions proposed later in this Appendix and to be continued as tentative in the proposed revised form.

Section 48.—Add a new Paragraph (*c*) reading as follows:

(*c*) In case of conflict between the provisions of these methods and those of the detailed specifications for a particular material, the latter shall take precedence.

Section 50.—Change this section from its present form: namely,

50. No tests shall be made within 48 hours after vulcanization unless agreed to by the manufacturer.

to read as follows:

50. No tests shall be made earlier than 24 hours nor later than 60 days after vulcanization except by mutual agreement between the purchaser and manufacturer.

Section 51. (b).—Change this section to read as follows by the addition of the italicized word and figure and the omission of those in brackets:

(*b*) The samples shall be kept at a temperature within these limits for at least [3 hours] *1 hour* immediately before being tested.

Section 52.—Change the last sentence to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

If it is necessary to use gasoline, it shall be of a grade which distills below [239° F. (115° C.)] *302.0° F.* (*150° C.*) and *which, upon evaporation, does not*

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 795 (1929); also 1930 Book of A.S.T.M. Tentative Standards, p. 673.

leave an appreciable amount of oily residue. After use of gasoline, the specimen shall be allowed to rest at least one hour before being tested.

Figure 1.—Change drawing "(*a*) ½ by 2-in. Specimen" so that the 1¼-in. end dimension is illustrated. The center of the 1 in. radius will then be shown free and not fixed at the edge of the specimen. The revised drawing is illustrated in the accompanying Fig. 1.

Section 54 (*d*).—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*d*) The thickness shall be measured with a micrometer graduated to 0.001 in. having circular shoes 0.24 to 0.26 in. in diameter and with a pressure on the specimen of [not less than 8 oz. nor more than 10 oz.] *9 oz. ± 0.1 oz.*

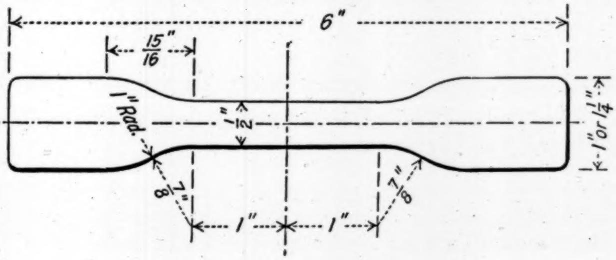

FIG. 1.—½ by 2-in. Specimen.

Section 59 (*a*).—Change the second sentence of the second paragraph of this section to read as follows by the addition of the italicized figure and the omission of that in brackets:

The distance through which separation takes place shall be noted for a period of [10] *4* minutes if possible.

Sections 60 to 62.—Change part (*C*) Hydrostatic Tests of Hose from its present form to read as follows:

60. Application and Measurement of Pressure.—The pressure tests for hose shall be made with water by means of a hand or power-driven pump or by means of an accumulator system. The hose shall be connected to the water line or pump and filled with water allowing the air to escape through an air cock. Removal of the air is important for the sake of safety. When the hose is filled with water, the air cock shall be closed and if original measurements of the hose are required, the pressure shall then be raised to 10 lb. per sq. in. and held there while the measurements are taken. The pressure shall then be increased at a uniform rate of approximately 1000 lb. per sq. in. per minute except in the case of fire hose or when otherwise required by detailed specifications. With fire hose, a rate of increase of pressure of 300 lb. per sq. in. per minute shall be used. The pressures shall be measured with a calibrated gage.

61. Time Pressure Tests.—The pressure shall be increased at the specified rate until the designated pressure is reached and held at that pressure for the specified time during which time the hose shall not leak nor burst. The water pressure shall be held approximately constant during this test. In no case shall the pressure exceed that designated nor should it oscillate to a point more than 10 per cent below the specified pressure.

62. Bursting Test.—The pressure shall be increased at the specified rate until failure and the pressure at which failure occurs shall be considered the bursting strength of the hose and shall be not less than that specified. It is permissible to determine the bursting strength on the same sample immediately following the time pressure test if both are required.

63. Retests.—If a sample fails in the hydrostatic pressure test, two additional samples shall be tested and if either of these fails, the entire lot of hose represented by the samples shall be considered to have failed to meet the specifications.

PROPOSED REVISIONS OF TENTATIVE STANDARDS

Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 – 28 T):[1]

Section 5.—Change this section from its present form: namely,

> 5. The stranding shall be concentric and unless otherwise specified shall conform to either Table I or Table II.

to read as follows:

> 5. The stranding shall conform to the requirements of Table I and shall be either standard concentric or flexible as specified in the order.

Tables I and II.—Replace the present Tables I and II with the accompanying new Table I on Stranding of Insulated Conductors, renumbering all subsequent tables and table references in the text accordingly:

TABLE I.—STRANDING OF INSULATED CONDUCTORS.

For intermediate sizes use stranding for next larger size.

Conductors of No. 0000 and smaller are often made solid and this table of stranding should not be interpreted as excluding such practice.

In assembly column, "37 by 19 rope lay," signifies 37 strands of 19 wires assembled like a rope.

Size of Conductors	Standard Concentric Stranding,[a] Number of Wires	Flexible Stranding	
		Number of Wires	Assembly
2 000 000 cir. mils	127	703	37 by 19 rope lay
1 500 000 cir. mils	91	703	37 by 19 rope lay
1 000 000 cir. mils	61	427	61 by 7 rope lay
500 000 cir. mils	37	427	61 by 7 rope lay
300 000 cir. mils	37	259	37 by 7 rope lay
0 000 A. w. g	19	133	19 by 7 rope lay
1 A. w. g	19	91	Concentric
2 A. w. g	7	91	Concentric
4 A. w. g	7	61	Concentric
10 A. w. g	7	37	Concentric
16 A. w. g	7	26	Bunched
18 A. w. g	7	16	Bunched
20 A. w. g	7	10	Bunched

[a] The standard concentric stranding in this table agrees with Table XII of *Circular No. 31*, "Copper Wire and Cables," U. S. Bureau of Standards; and also Table II of Standard No. 30 "Wires and Cables" of the American Institute of Electrical Engineers.

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[1] ***Proceedings*****, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1033 (1928); also 1930 Book of A.S.T.M. Tentative Standards, p. 652.**

Part (B) Insulation, Sections 12 to 16.—Change Sections 12 to 16, inclusive, from their present form to read as follows, renumbering the subsequent sections accordingly:

12. *Workmanship.*—(*a*) The insulation shall be of either Class A or Class AO rubber compound as specified in the order. Where neither class is specified, the manufacturer may supply either class.

(*b*) The insulation shall consist of a properly vulcanized rubber compound which shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer, adjacent layers shall be vulcanized into a homogeneous mass.

(*c*) Tape used over insulation during vulcanization will be accepted as tape under these specifications provided it conforms to the requirements of Sections 46 to 49, inclusive (the present Sections 45 to 48).

(*d*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 18 (the present Section 17).

MANUFACTURE

13. *Composition.*—(*a*) The insulation shall consist of either Class A or Class AO rubber compound.

Class A rubber compound shall contain exclusively not less then 30 per cent nor more then 33 per cent of the best quality Hevea rubber which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sufficient sulfur to properly vulcanize the compound.

Class AO rubber compound shall contain the same ingredients as Class A with the addition of antioxidants and organic accelerators.

(*b*) The mineral matter shall be dry and Class A insulation shall be free from organic materials.

(*c*) The waxy hydrocarbons used shall be solid at 54° C. and shall be free from saponifiable matter.

(*d*) Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to these specifications.

CHEMICAL PROPERTIES

14. *Quantitative Requirements.*—The insulation after vulcanization shall conform on analysis to the following requirements expressed as percentages by weight of the whole sample:

CLASS A AND CLASS AO	MAXIMUM	MINIMUM
Rubber, per cent	33	30
Waxy Hydrocarbons, per cent	4	..
Free Sulfur, per cent	0.7	..

	30-PER-CENT RUBBER[a] MAXIMUM	30-PER-CENT RUBBER[a] MINIMUM	33-PER-CENT RUBBER[a] MAXIMUM	33-PER-CENT RUBBER[a] MINIMUM
Saponifiable Acetone Extract, per cent				
Class A	1.35	0.55	1.50	0.60
Class AO	2.00	....	2.20	....
Unsaponifiable Resins, per cent				
Class A	0.45	....	0.50	....
Class AO	1.00	....	1.10	....
Chloroform Extract, per cent				
Classes A and AO	0.90	....	1.00	....
Alcoholic Potash Extract, per cent				
Classes A and AO	0.55	....	0.60	....
Total Sulfur, per cent				
Classes A and AO	2.10	....	2.30	....

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[a] For percentages between 30 and 33, the limits shall be in proportion to the percentage of rubber found.

15. *Qualitative Requirements.*—(*a*) The acetone solution from either compound shall not fluoresce and the acetone extract (60 ml.) from Class A compound shall not be darker than a light straw color.

(*b*) The hydrocarbons shall be solid, waxy and not darker than a light brown.

(*c*) The chloroform extract (60 ml.) shall not be darker than a straw color.

PHYSICAL PROPERTIES

16. *Physical Properties.*—The insulation shall conform to the following requirements as to physical properties:

	MAXIMUM	MINIMUM
Tensile Strength, lb. per sq. in.		
Class A	..	1000
Class AO	..	1200
CLASS A AND CLASS AO		
Set in 2-in. gage length	$\frac{3}{8}$	....
Elongation at rupture in 2-in. gage length, per cent	..	350
Specific gravity, 30 per cent rubber	..	1.75[a]
Specific gravity, 33 per cent rubber	..	1.67[a]

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[a] For percentage between 30 and 33, the specific gravity limit shall be in proportion to the percentage of rubber found.

17. *Aging Tests.*—Class AO rubber compound shall be subjected to the following tests:

(*a*) When subjected to the accelerated aging test, known as the Geer test, for 96 hours at 70° C., the rubber insulation shall show a depreciation of not more than 15 per cent in elongation or tensile strength.

(*b*) When subjected to the accelerated aging test, known as the "Oxygen Bomb test," for 96 hours at 300-lb. pressure and 70° C., the rubber insulation shall show a depreciation of not more than 25 per cent in elongation or tensile strength.

(*c*) Samples submitted for aging tests shall have no protective covering and shall be prepared as described in Section 26 (*a*). They shall be suspended vertically and free from contact with metal during the test. Depreciation due to aging shall be determined by testing the aged and unaged samples at the same time and within 24 hours after the completion of the aging tests.

Table IV.—Under "Size of Conductor," change the first line in the first column to read "No. 14 to No. 9" and the second line to read "No. 8 to No. 2" in place of "No. 14 to No. 8" and "No. 7 to No. 2," with corresponding changes in the millimeter equivalents.

Table V.—In the column under "Size of Conductors" change the first line in the first column to read "No. 14 to No. 9" and the second line to read "No. 8 to No. 6" in place of "No. 14 to No. 8" and "No. 7 to No. 6."

Section 25 (b).—Change the last sentence of this section from its present form: namely,

> No tests shall be made within 48 hours after vulcanization unless agreed to by the manufacturer.

to read as follows:

> Tests shall be made not earlier than 24 hours nor later than 60 days after the vulcanization unless approved by the manufacturer.

Part (C) Rubber-Filled Cloth Tape.—Change the title of this part to read "*Cable Tape.*"

Section 45.—Renumber as Section 46 and change to read as follows by the addition of the italicized words:

> 46. The tape shall be made from cotton cloth having a weight of not less than one pound per four yards with a width of 36 in. and not less than 56 by 60 picks per inch and shall be *frictioned on both sides and* thoroughly filled with a rubber compound.

Table VIII.—Change from its present form to read as follows:

TABLE VIII.—WIDTH AND OVERLAP OF RUBBER-FILLED CABLE TAPE.

DIAMETER OVER INSULATION, IN.	MAXIMUM WIDTH OF TAPE, IN.	MINIMUM OVERLAP, IN.
2.00	4	½
1.75	3½	⅜
1.50	3	⅜
1.25	2½	⅜
1.15	2½	⅜
1.00	2	¼
0.88	2	¼
0.75	1½	¼
0.62	1½	¼
0.50	1	¼
0.38	1	¼
0.31	¾	⅛
0.25	¾	⅛
0.19	¾	⅛
0.16	¾	⅛

For intermediate diameters the requirements shall be those of the next smaller size.

Part (D) Braid, Sections 49 to 52.—Change Sections 49 to 52, inclusive, from their present form to read as follows, renumbering as Sections 50 to 53:

50. *Braid.*—Cotton braids where specified shall be applied in accordance with Table IX.

TABLE IX.—THICKNESS AND WEAVE OF COTTON BRAID.

For twin cable, use the mean diameter.

Where two braids are specified, the outer braid shall be determined by the diameter after the first braid has been applied.

Equivalent braids having the same number of picks, the same thickness, and having a greater number of plies, will be accepted under these specifications.

This table does not apply to braids for fixture wire or for fancy or special braids.

Where two braids are applied with double deck braiders, this table shall apply to the outer and inner braids, except that the picks per inch and average angle of lay for the inner braid shall be governed by the construction of the machine.

A tolerance of 5 per cent below the value specified shall be allowed on both picks per inch and braid angles.

Diameter Under Braid, in.	Average Angle of Lay, deg.	Minimum Thickness of Braid, in.	Cotton Size, Ply and Ends	Average Picks, per Inch	Cotton Size, Ply and Ends	Average Picks per Inch
			12-Carrier Braiders		16-Carrier Braiders	
Less than 0.124	40	0.020	20/2/2	24	20/2/2	20
0.125 to 0.149	40	0.020	20/2/2	25	20/2/2	23
0.150 to 0.199	40	0.020	20/2/3	18	20/2/3	16
0.200 to 0.249	40	0.0225	....	....	16/2/3	15
0.250 to 0.299	40	0.0225	....	....	16/2/3	16
			20-Carrier Braiders		24-Carrier Braiders	
0.150 to 0.199	40	0.020	20/2/2	22	20/2/2	20
0.200 to 0.249	40	0.0225	16/2/2	20	16/2/2	20
0.250 to 0.299	40	0.0225	16/2/3	14	16/2/3	13
0.300 to 0.349	45	0.026	12/2/3	12	12/2/3	12
0.350 to 0.399	45	0.026	12/2/3	13	12/2/3	12
0.400 to 0.449	45	0.026	12/2/3	13	12/2/3	13
0.450 to 0.499	50	0.026	12/2/3	13	12/2/3	14
0.500 to 0.599	50	0.026	12/2/3	14	12/2/3	14
0.600 to 0.799	55	0.0315	....	....	8/2/3	12
0.800 to 0.999	60	0.0315	....	....	8/2/4	9.5
			36-Carrier Braiders		48-Carrier Braiders	
1.000 to 1.499	50	0.037	6/2/2	12	6/2/3	9.5
1.500 to 1.799	60	0.045	4/2/2	11.5	4/2/3	9.0
1.800 to 2.149	65	0.051	4/3/2	10.5	4/3/2	9.5
2.150 to 2.499	70	0.051	4/3/2	9.5	4/3/2	9.0
2.500 to 3.000	70	0.067	4/4/2	9.0	4/4/2	9.0

51. *Coverings.*—Wires up to No. 7 A. w. g. inclusive shall be covered with a single braid. On larger wires the fiberous coverings shall consist of a tape and a braid. In multiple conductor cables the individual conductors shall not be braided. If other coverings are desired, such as two braids in place of a tape and braid, it shall be so stated in the order.

The tape shall conform to Sections 46 to 49, inclusive, and the braid to Section 50.

52. *Finish.*—The braid shall be completely saturated with a weather-resisting compound and finished with a black waxy insulating compound thoroughly slicked down.

53. *Compound.*—The saturating and finishing compounds shall have no injurious effect upon the rubber insulation or the coverings at a temperature of 90° C. (194° F.) and shall meet the following tests:

(*a*) *Moisture Absorption Test.*—A 6-in. sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20° C. (68° F.) for a period of 24 hours. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion.

(*b*) *Melt Test.*—A 6-in. sample of wire with the insulation removed for $\frac{1}{2}$ in. at each end shall be placed on clean, white glazed paper and maintained at 52° C. (125° F.) for 30 minutes. The compound shall not migrate sufficiently to produce distinct marking on the paper. Markings produced by the sample at room temperature will be disregarded.

New Sections.—Introduce three new sections under a central heading "(*E*) Lead Sheaths" reading as follows, relettering the present heading on inspection, "*E*" as "*F*" and renumber the sections accordingly:

54. *Composition.*—Lead sheaths shall consist of commercially pure lead (approximately 99.85 per cent) without flaws and tightly formed about the taped core of the cable.

55. *Thickness.*—Lead sheaths shall have an average thickness not less than that indicated in Table X and the minimum thickness shall in no place be less than 90 per cent of the required average thickness:

TABLE X.—THICKNESS OF LEAD SHEATHS.

DIAMETER OF CORE, IN.[a]	THICKNESS OF SHEATH IN $\frac{1}{64}$ IN.
Over 3.000	9
2.001 – 3.000	8
1.501 – 2.000	7
1.051 – 1.500	6
0.701 – 1.050	5
0.426 – 0.700	4
0.000 – 0.425	3

[a] For twin cables, use the major axis.

56. *Measurement.*—A short section of the lead sheath shall be removed from the wire or cable and the thickness measured with a suitable micrometer caliper at not less than ten points, approximately equally spaced, care being taken to include the thinnest and the thickest parts.

Tentative Specifications for Steam Hose (D 54 – 24 T):[1]

Section 9 (*b*).—In the table following this section, change the manner of expressing the values for elongation at rupture as follows by the addition of the italicized words and figures and the omission of those in brackets:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 1059 (1924); also 1930 Book of A.S.T.M. Tentative Standards, p. 648.

	Before Steam Test	After Steam Test
Elongation at rupture....	[2 in. to 6 in.] *200 per cent*	[2 in. to 4 in.] *100 per cent*

This change is recommended since 2-in. specimens cannot be obtained transversely as required in Section 9 (*a*) from several of the standard sizes and 1-in. specimens must be used. The revised statement involves no change in values and makes possible more effective wording of Section 11.

Section 11.—Change the last sentence of this section from its present form: namely,

> Furthermore, for the tube these values shall not be more than 50 per cent less than the values obtained before steaming and for the cover not more than 60 per cent less than the values obtained before steaming.

to read as follows:

> Furthermore, after the steam test, the tensile strength and elongation of the tube and the cover shall not show an increase or decrease of more than 40 per cent of the original results.

This change represents an improvement in quality and is in accord with experience with American Railway Association hose.

Section 12 (*b*).—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> (*b*) The hose upon examination immediately after its removal from the rack shall disclose no blistering of the tube [or] *nor* loosening of the tube from the fabric [nor shall]. *After steaming,* the inside diameter *of the hose shall not* be more than 15 per cent greater than the original diameter *for sizes having a nominal inside diameter under* $\frac{3}{4}$ *in. nor more than 13 per cent greater for sizes of* $\frac{3}{4}$ *in. and larger nominal inside diameters.*

This change is desirable in that it further limits the expansion for the larger sizes under steaming conditions.

Section 13.—Add the expression "nor show leaks" after the phrase "shall not burst."

Section 14 (*b*).—Since the instruments for measuring thickness are graduated in thousandths of an inch, express the cover thickness as 0.063 in. instead of $\frac{1}{16}$ in. and the tube thickness as 0.125 in. instead of $\frac{1}{8}$ in.

Section 17 (*b*).—Change from its present form: namely,

> (*b*) In the case of failure to pass any one of the tests specified in Sections 9 to 13, inclusive, the entire lot of hose represented by the sample, or samples, subjected to these tests, shall be rejected.

to read as follows:

> (*b*) Any material which fails in one or more of the tests specified in Sections 9 to 13, inclusive, may be resampled and retested at the expense of the manu-

facturer. For this purpose, two additional samples shall be selected from the hose for the test which failed to meet the requirements. Failure of either of the retested samples shall be cause for final rejection.

The above retest provision is in accord with the U. S. Government Specifications 49-b for Steam Hose and is desirable because of the generally recognized limitations in accuracy of physical testing methods. The provision assists in arriving at true results for the values specified.

Tentative Methods of Chemical Analysis of Rubber Products (D 297 - 29 T):[1]

Section 13.—In the table of check limits following this section change the tolerance for organic acetone extract from "0.10 per cent" to read "0.20 per cent."

Section 15 (a) Acetone Extract.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> If the acetone extraction is made on [a] vulcanized compound, the acetone removes the rubber resins, the free sulfur, any mineral oils or waxes, *any acetone-soluble antioxidants and organic accelerators or their decomposition products* and part of any bituminous substances or vulcanized oils that may have been used. This is generally called acetone extract uncorrected. The percentage of free sulfur and the percentage of waxy hydrocarbons are determined and their sum deducted from the total extract. The value obtained is known as acetone extract corrected. The corrected figure thus obtained will at times give valuable information regarding the quality of the rubber present. *This is not true, however, when the compound contains substantial quantities of mineral oils or waxes, bituminous substances, organic accelerators or antioxidants which have been added. With compounds containing rubber value which consists of only* [For] the best grades of Hevea rubber [this] *the acetone extract* should not exceed 5 per cent of the rubber present. A higher extract may indicate the presence of inferior or reclaimed rubbers, *added oils, waxes or bituminous materials or substantial quantities of organic accelerators or antioxidants. No correction is possible for small quantities of antioxidants and organic accelerators, since no general method is now known for the separation and identification of all classes of these materials.*

Section 55.—Change the formula for calculation of percentage of rubber by volume following this section to read as follows by the omission of the word in brackets:

$$\text{Percentage of rubber by volume} = \frac{\text{Percentage of rubber as compounded} \times \text{sp. gr. of compound}}{0.94 \text{ (taken as the average sp. gr. of [crude] rubber)}}$$

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 795 (1929); also 1930 Book of A.S.T.M. Tentative Standards, p. 673.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials has held two interesting and productive meetings since the 1930 annual meeting of the Society. One was held in Boston, Mass., on October 16 and 17, 1930, and one in New York City, on March 12 and 13, 1931. A third meeting will be held in conjunction with the annual meeting of the Society in June. The registration of members and guests at the October meeting was 51 and at the March meeting 69. This fine attendance at both two-day sessions indicates the continued interest of the personnel of this committee.

The following papers were presented at the meetings:

"The Newer Developments in Textile Microscopy," by E. R. Schwarz;

"Future Textile Laboratory Practice," by G. B. Haven;

"Notes on a New Device for Recording the Evenness of Raw Silk," by W. F. Edwards;

"An Apparatus for Measuring the Thermal Transmission of Textiles," and "Relation Between Twist and Certain Properties of Number 10's Cotton Yarn and of Fabrics made from It," by H. F. Schiefer.

At the October meeting appropriate action was taken in memory of William D. Hartshorne, the first chairman of Committee D-13, whose death occurred on September 3, 1930.

A new Subcommittee on Silk is in process of organization and Mr. H. S. Bishop of John Dunlop's Sons, Inc., has been appointed as chairman. The personnel is not complete at the present time but the expectation is that this subcommittee will be functioning in the fall.

The present membership of the committee is now 158, of whom 63 are classed as producers, 43 as consumers, and 52 as general interests.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee regarding standards and tentative standards under its jurisdiction are summarized below together with the analysis of the letter ballot on each item. Comments, where necessary, are made under Subcommittee Activities.

I. New Tentative Standards.—The committee recommends for publication as tentative the following four new tentative standards as appended hereto:

Proposed Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating;[1]

Proposed Tentative Specifications for Enameling Duck for the Tire Industry;[2]

Proposed Tentative Specifications for 0.007-in. Cotton Tape;[3]

Proposed Tentative Method of Determining Relative Humidity.[4]

II. *Proposed Revision of Standard.*—The committee recommends that the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 – 27)[5] be completely revised, as appended hereto.[6] The revisions consist of a deletion of the word "electrical" from the title, a substitution of the word "tape" for "fabric" or "narrow fabric" whenever it occurs in the specifications, a change in the wording of Sections 4, 6, 7, 10, 11, and 14 and the addition of a new Section 20 which takes the place of the note in the present Section 16. Due to the extensive nature of the changes, the revision has been issued in the form of a separate tentative standard which will supersede the present standard when adopted.

The revision proposed in 1930 of the Standard Specifications for Textile Testing Machines (D 76 – 27)[7] which involved a patented device was accepted last year for publication as tentative subject to the approval of the Executive Committee of the Society after reviewing the situation in respect to patent features. The Executive Committee has recently granted permission to Committee D-13 to include reference to certain patented devices in the specifications upon satisfactory assurance of the owner of the patent that the patent will not result in an exorbitant price of these devices to the consuming public. This proposed revision of the specifications, which reads as follows, will accordingly be published as tentative:

Section 5 (*a*) *Fabric Jaws.*—Add the following new paragraph to this section:

> In the case of vertical or upright testing machines, where the upper jaws are not held in positive alignment, it is recommended that the lower jaw of the testing machine be provided with two tapered pins one on each side about ½ in. in diameter which project upward and are adjustable for different spacing between the top and bottom jaws. The upper ends of these pins shall fit into the tapered holes in the upper jaw when placing the specimen but disengaging when the jaws separate. In this way they regulate the distance between the jaws and hold them in positive alignment while the test specimen is being inserted.

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[1] See p. 982.—Ed. [2] See p. 993.—Ed. [3] See p. 988.—Ed. [4] See p. 1005.—Ed.

[5] 1930 Book of A.S.T.M. Standards, Part II, p. 1093.

[6] See p. 990.—Ed.

[7] 1930 Book of A.S.T.M. Standards, Part II, p. 1060.

III. *Proposed Revisions of Tentative Standards.*—The committee recommends that the following two tentative specifications and one tentative method be revised and continued as tentative:

Tentative Specifications for Chafer Tire Fabrics (D 316 – 30 T),[1] completely revised as appended hereto.[2] The revisions consist chiefly in a rearrangement of the subject matter and the inclusion of methods of testing.

Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 – 27 T)[3] completely revised as appended hereto.[4] Sections 14 to 21 inclusive, which describe a preferred and alternate method of testing for size or yarn number (denier) of rayon, have been rewritten and replaced by ten new paragraphs. The substance of these changes is to substitute the present alternate method for the preferred, and *vice versa,* and to make other necessary editorial changes. Section 33 has been revised by omitting the Note and changing the standard moisture regain of nitro-cellulose, viscose, and cuprammonium rayons from 14.5 per cent of the dry weight to 11 per cent.

Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 – 30 T).[5] In these tentative methods the committee recommends that the entire procedure for Differentiation of Rayons be deleted and a new Identification procedure substituted; this new procedure being identical with the methods for identification of rayons described in Sections 3 to 6 of the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 – 31 T), appended hereto.[4]

IV. *Tentative Standards Continued as Tentative.*—The committee recommends that the following tentative standards be continued as tentative for another year without revision:

Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 – 28 T);

Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T);

Tentative Methods of Testing Grease Wool and Allied Fibers for Scoured Content (D 232 – 25 T); and

Tentative Definitions of Terms Relating to Textile Materials (D 123 – 30 T).

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1229 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 717.

[2] See p. 1000.—ED.

[3] *Proceedings,* Am. Soc. Testing Mats., Vol. 27, Part I, p. 1032 (1927); also 1930 Book of A.S.T.M. Tentative Standards, p. 699.

[4] See p. 974.—ED.

[5] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1231 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 723.

The above recommendations have been submitted to letter ballot of the committee, which consists of 158 members; 71 ballots have been cast, 87 members having failed to return their ballots. The analysis of the vote is given in the following table:

Items	Affirmative	Negative	Not Voting
I. Proposed New Tentative Standards			
Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating	38	1	32
Tentative Specifications for Enameling Duck for the Tire Industry	37	3	31
Tentative Specifications for 0.007-in. Cotton Tape	31	1	39
Tentative Method of Determining Relative Humidity	55	2	12
II. Proposed Tentative Revision of Standards			
Standard Specifications for Textile Testing Machines (D 76 - 27)	28	1	14
Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 - 27)	30	1	40
III. Proposed Revision of Tentative Standards			
Tentative Specifications for Chafer Tire Fabrics (D 316 - 30 T)	35	3	33
Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 27 T)	36	2	33
Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 - 30 T)	43	0	28

Subcommittee Activities

Subcommittee A-1 on Cotton (K. B. Cook, chairman):

Section I on Cotton (H. H. Willis, chairman).—This section will undertake some experiments on raw cotton manufactured into certain counts of yarn with a view to studying three properties, (1) flexing resistance (2) ability to stand repeated stress and (3) strength. The tests and check tests on representative samples of these yarns will be conducted in a modern laboratory under carefully controlled atmospheric conditions.

Section II on Cotton Yarns and Threads (R. H. Adams, chairman).—This section is making a survey to determine the advisability of preparing specifications for sewing thread and cotton yarn.

Section III on Light and Medium Cotton Woven Fabrics (R. T. Fisher, chairman).—This section is presenting for publication as tentative proposed Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating.[1] The acceptance of this proposed tentative standard will add a large group of certain staple sheetings, drills, twills, broken twills, and sateens to the list of fabrics covered by specific specifications. This specification in its original form was drawn up under the auspices of The Association of Cotton Textile Merchants of New York, The Cotton Textile Institute, Inc., The Association of Pyroxylin Coated Fabric Manufacturers, and The Automobile Fabric Manufacturers Division of the Rubber Manufacturers Association, Inc., by a committee composed of both manufacturers and consumers. It is presented here with only such minor changes as are necessary to make it conform to the usual form.

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[1] See p. 982.—Ed.

Section IV on Tire Fabrics (B. H. Foster, chairman).—This section is presenting for publication as tentative Proposed Specifications for Enameling Duck for the Tire Industry.[1] It has also made a complete revision of the Tentative Specifications for Chafer Tire Fabrics (D 316 – 30 T), and recommends that the specifications as thus revised, as appended hereto,[2] remain tentative for another year. Both of the above-named specifications have been made more complete by the inclusion of tolerances and test methods.

The section also conducted a test for the purpose of determining the proper strength correction factors for chafer fabrics and enameling duck. Seven members of the committee took active part in this test. From the results obtained the committee has set a correction factor of 4.7 for chafer fabrics, and 4.2 for enameling duck, and the method of correcting strength to a standard moisture regain has been included in the test methods for both types of fabrics.

Work has been started on collecting data for the purpose of drawing up tentative specifications for breaker fabrics.

Section V on Hose, Belt and Numbered Duck (B. L. Whittier, chairman).—This section has concluded the study, mentioned in the last annual report,[3] of a new type of jaw for testing heavy fabrics. The tests did not show any better results and the subject has been dropped.

The section has canvassed about twenty-five rubber companies in regard to the advisability of preparing standard specifications for hose and belting duck. Lack of interest on their part has caused the section to defer action on specifications for these materials until a later date. It is planning to hold a special meeting in the near future to determine on its next line of activity.

The chairman of this section represented Committee D-13 at a recent conference in Washington under the auspices of the Department of Commerce to consider matters relating to tent ducks and tarpaulins.

Section VI on Narrow Fabrics (F. S. Mapes, chairman).—This section is presenting for publication as tentative Proposed Specifications for 0.007-in. Cotton Tape.[4] It has also completed and presents herewith, as appended hereto,[5] for publication as tentative a revision of the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 - 27).

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[1] See p. 993.—ED.

[2] See p. 1000.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 856 (1930).

[4] See p. 988.—ED.

[5] See p. 990.—ED.

This section is planning to prepare specifications for tolerances and test methods for braided tubular cotton sleeving. It is conducting a study of methods for determining the sizing content in cotton tapes, and further plans to correlate such information as is available for determining their acidity or alkalinity.

Section VII on Osnaburg Cement Bags (W. D. Lober, chairman).—This section reports that its inactivity is due to the continuing trend toward the use of paper bags which is practically eliminating the use of osnaburg for this purpose.

Subcommittee A-2 on Rayon (A. M. Tenney, chairman):

Section I on Rayon (A. M. Tenney, chairman).—The activities of this section during the year have resulted in two revisions of the Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 - 27 T). The first change was in the methods of identification of the various types of rayon. In this work the section has received the collaboration of Section I on Methods of Subcommittee B-1 on Methods and Machines. The identification methods originally specified were entirely rewritten and more satisfactory procedures substituted. This revision was submitted by Committee D-13 to Committee E-10 on Standards for publication as tentative.[1] The revisions as recommended by the committee were approved by Committee E-10 on February 20, 1931. The revised identification methods have been included in the revised tentative standard appended hereto.[2]

The committee is also recommending another revision of these tentative specifications which calls for an interchange of the present alternate and preferred methods of determining yarn size (denier); it also makes an important change in the standard of moisture regain for nitro-cellulose, viscose, and cuprammonium rayons, reducing it from 14.5 per cent to 11 per cent. These changes have been incorporated in the revised specifications appended hereto[2] which are recommended for continuation as tentative for another year.

The section has continued its cooperation with the Bureau International pour la Standardisation des Fibres Artificielles, Basle, Switzerland, for the purpose of producing as complete an agreement as possible between the methods used by the European organization and the American Society for Testing Materials.

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[1] In submitting these specifications to Committee E-10, the Committee reported the results of the letter ballot vote as follows: 69 members returned their ballots of whom 31 voted affirmatively, 1 negatively, and 37 refrained from voting.

[2] See p. 974.—ED.

Section II on Rayon Fabrics (A. Sommaripa, chairman).—Under the direction of the chairman of this section, outside research work has been carried on as to the best methods of testing rayon fabrics. It is planned to hold a special meeting of this section in the near future to consider the preliminary reports on this work.

Subcommittee A-4 on Asbestos:

Section I on Asbestos Textiles (J. M. Weaver, chairman).—This section in the near future expects to present for approval a revision of the Tentative Specifications for Asbestos Tape for Electrical Purposes (D 315 – 29 T).

The increase in the personnel of this section is a sign of healthy interest in its work. The section is considering the question of developing a method for the determination of the magnetic iron content of asbestos. This is obviously a problem of great importance to users of asbestos for electrical purposes.

Subcommittee A-5 on Jute, Ramie and Linen:

Section I on Sugar Bags (A. E. Davieau, chairman).—In respect to the Tentative Specifications and Tests for Cuban (Jute) Raw Sugar Bags (D 275 – 27 T), the situation seems to be unchanged from a year ago. Efforts are still in progress to secure the recognition of these specifications by the Indian Jute Mills Association of Calcutta and in view of this the recommendation is made that the specifications be continued as tentative for another year.

Subcommittee B-1 on Methods and Machines (W. D. Appel, chairman):

Section I on Methods (W. D. Appel, chairman).—During the past year this section has been working on the elimination of unnecessary variations in similar test methods used in different specifications.

It has collaborated with Section I of Subcommittee A-2 on Rayon upon the problem of identification of the various types of rayon. Satisfactory methods have been evolved, upon which, as noted above, appropriate action has already been taken by that section. This section is recommending that the same changes be made in the Tentative Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods (D 276 – 30 T), and that the specifications as thus revised be continued as tentative for another year.

The section has under consideration the need of a test for slippage, particularly in connection with rayon and silk fabrics.

Section II on Machines (H. J. Ball, chairman).—The work of this section in its study of abrasion methods and the measurement of their effect has been temporarily interrupted because of the demand upon the time of the chairman, who is at present serving as chairman of the entire Committee D-13.

Section III on Humidity (G. B. Haven, chairman).—This section is presenting for publication as tentative Proposed Tentative Methods of Determining Relative Humidity.[1] It is also offering in the Appendix to this report a psychrometric table in a form which it believes will be found to be most convenient for use.

The recommendation of this section that a tolerance of +10° F. in the temperature requirement of a standard atmosphere as defined in the Standard Definitions of Terms Relating to Textile Materials (D 123 – 30) has been approved by Committee D-13. This tolerance will be incorporated in subsequent revisions of specifications involving a standard atmosphere.

This section is continuing its study and collection of data in regard to moisture regain in various kinds and types of textile fibers and materials.

Subcommittee B-2 on Nomenclature and Definitions (A. L. Brassell, chairman).—This section has been working upon a revision of the definitions of terms now appearing in the Standard Definitions of Terms Relating to Textile Materials (D 123 – 30) and in the Tentative Definitions of Terms Relating to Textile Materials (D 123 – 30 T). It expects in the near future to be in a position to expand the lists of terms in the above definitions and thus to make available a fairly comprehensive glossary of textile fibers and materials.

Subcommittee B-4 on Bleaching, Dyeing, and Finishing (W. M. Scott, chairman).—This section has only recently been organized under a new chairman and has had no opportunity as yet to function. It is at the present moment laying out a program of work. The chairman of this subcommittee represented the Society at a recent preliminary inter-society conference on color specifications.

This report has been submitted to letter ballot of the committee, which consists of 158 members; 63 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

H. J. BALL,
Chairman.

W. H. WHITCOMB,
Secretary.

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[1] See p. 1005.—ED.

EDITORIAL NOTE

The proposed Tentative Specifications and Test Methods for Cotton Goods for Rubber and Pyroxylin Coating, Specifications for Enameling Duck for the Tire Industry, for 0.007-in. Cotton Tape and Method of Determining Relative Humidity were accepted for publication as tentative and appear on pages 982, 993, 988 and 1005, respectively.

The proposed revision of the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes in the form of new tentative specifications entitled Tentative Specifications for Tolerances and Test Methods for Silk and Cotton Tapes were accepted for publication as tentative and appear on page 990.

As announced in the Summary of Proceedings, see page 21, the revision proposed in 1930 of the Standard Specifications for Textile Testing Machines which involved a patented device has now been approved by the Executive Committee and appears on page 1061.

The proposed revisions of the Tentative Specifications for Chafer Tire Fabrics, for Tolerances and Test Methods for Rayon and Methods for Identification of Textile Fibers and Their Quantitative Determination in Mixed Goods were accepted. The specifications and methods in their revised form appear on pages 1000, 974 and 1009, respectively.

Subsequent to the annual meeting, the committee approved a revision of the Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes which was accepted on August 6 by Committee E-10 on Standards. The specifications in their revised form appear on page 996.

APPENDIX

PSYCHROMETRIC TABLE FOR RELATIVE HUMIDITY

In the Tentative Method of Determining Relative Humidity (A.S.T.M. Designation: D 337 – 31 T) of the American Society for Testing Materials,[1] the following formula is given in Section 5 (*a*) for computing vapor pressure, e, from observed readings of the wet and dry bulb psychrometer:

$$e = e' - 0.000367P\,(t - t')\left(1 + \frac{t' - 32}{1571}\right) \dots\dots\dots (1)$$

Relative humidity may then be calculated from the formula:

$$\text{Relative humidity, per cent} = \frac{100e}{E} \dots\dots\dots\dots (2)$$

Values of saturated vapor pressure, e' and E, referred to in the above are found in Smithsonian Meteorological Tables,[2] having been computed according to a formula given in those tables.

Even using the computed values of saturated vapor pressure, determination of relative humidity by substitution in formulas 1 and 2 above is a tedious matter, as indicated by the following example:

Given the following data:

t, the dry bulb temperature, = 73.0° F.
t', the wet bulb temperature, = 65.0° F.
P, the barometric pressure, = 30.0 in. of mercury

Then by reference to the Smithsonian Tables:[2]

e', the saturated vapor pressure at temperature $t' = 0.6226$ in. of mercury
E, the saturated vapor pressure at temperature $t = 0.8191$ " " "

By substitution:

$$e = 0.6226 - 0.000367(30)8.00\left(1 + \frac{33.0}{1571}\right) \dots\dots\dots\dots\dots\dots\dots (1)$$

$$e = 0.5327$$

$$\text{Relative humidity} = \frac{100(0.5327)}{0.8191} = 65.0 \text{ per cent} \dots\dots\dots\dots\dots (2)$$

Tables or charts for quick determination of relative humidity without computation are essential in practical testing work. Several such tables, all based on the formulas given above, are available.

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[1] See p. 1005.—ED.

[2] See Table 70 of the *Smithsonian Meteorological Tables*, Smithsonian Inst., Washington, D. C., 4th revised edition, 1924.

TABLE I.—PSYCHROMETRIC HUMIDITY TABLE.[a]

(Relative Humidities Corresponding to Dry Bulb Temperatures and Wet Bulb Depressions of the Standard Sling Psychrometer—Barometer 30 in.)

Relative Humidity, per cent	Dry Bulb Temperature, deg. Fahr.																			
	0	5	10	15	20	25	30	32	34	36	38	40	42	44	46	48	50	52	54	56
	Wet Bulb Depression																			
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
96	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7
94	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0	1.0
92	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3
90	0.3	0.4	0.5	0.5	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.2	1.2	1.3	1.4	1.4	1.5	1.6	1.6	1.7
88	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.1	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.7	1.8	1.8	1.9	2.0
86	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.3	1.5	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.1	2.2	2.3	2.3
84	0.5	0.6	0.7	0.9	1.1	1.2	1.4	1.5	1.7	1.7	1.9	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7
82	0.5	0.7	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
80	0.6	0.7	0.9	1.0	1.3	1.5	1.8	1.9	2.1	2.2	2.3	2.4	2.6	2.7	2.8	2.9	3.0	3.2	3.3	3.4
79	0.6	0.8	1.0	1.1	1.4	1.6	1.9	2.0	2.2	2.3	2.4	2.6	2.7	2.8	3.0	3.0	3.2	3.3	3.5	3.6
78	0.7	0.8	1.0	1.2	1.5	1.7	2.0	2.1	2.3	2.4	2.5	2.7	2.8	3.0	3.1	3.2	3.3	3.5	3.6	3.7
77	0.7	0.8	1.0	1.2	1.5	1.8	2.1	2.2	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3.4	3.5	3.6	3.7	3.9
76	0.7	0.9	1.1	1.3	1.6	1.9	2.2	2.3	2.5	2.7	2.8	2.9	3.1	3.2	3.4	3.5	3.7	3.8	3.9	4.1
75	0.7	0.9	1.1	1.4	1.7	1.9	2.3	2.4	2.6	2.8	2.9	3.1	3.2	3.3	3.5	3.7	3.8	4.0	4.1	4.3
74	0.8	1.0	1.2	1.4	1.7	2.0	2.4	2.5	2.7	2.9	3.0	3.2	3.3	3.5	3.6	3.8	4.0	4.1	4.3	4.4
73	0.8	1.0	1.2	1.5	1.8	2.1	2.5	2.6	2.8	3.0	3.2	3.3	3.5	3.6	3.8	4.0	4.1	4.3	4.5	4.6
72	0.8	1.0	1.3	1.5	1.9	2.2	2.6	2.7	2.9	3.1	3.3	3.5	3.6	3.8	3.9	4.1	4.3	4.5	4.6	4.8
71	0.9	1.1	1.3	1.6	1.9	2.2	2.7	2.8	3.0	3.2	3.4	3.6	3.7	3.9	4.1	4.3	4.5	4.6	4.8	5.0
70	0.9	1.1	1.4	1.7	2.0	2.3	2.8	2.9	3.1	3.4	3.5	3.7	3.9	4.0	4.2	4.4	4.6	4.8	5.0	5.2
69	0.9	1.2	1.4	1.7	2.0	2.4	2.9	3.0	3.2	3.5	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4
68	1.0	1.2	1.5	1.8	2.1	2.5	3.0	3.1	3.3	3.6	3.7	4.0	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.6
67	1.0	1.2	1.5	1.8	2.2	2.6	3.1	3.2	3.4	3.7	3.9	4.1	4.3	4.4	4.7	4.9	5.1	5.3	5.5	5.7
66	1.0	1.3	1.5	1.9	2.3	2.7	3.2	3.3	3.5	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.3	5.5	5.7	5.9
65	1.0	1.3	1.6	2.0	2.3	2.7	3.2	3.4	3.7	3.9	4.1	4.3	4.5	4.7	5.0	5.2	5.4	5.6	5.9	6.1
64	1.1	1.3	1.6	2.0	2.4	2.8	3.3	3.5	3.8	4.0	4.2	4.4	4.7	4.9	5.1	5.4	5.6	5.8	6.0	6.3
63	1.1	1.4	1.7	2.1	2.5	2.9	3.4	3.6	3.9	4.2	4.4	4.6	4.8	5.0	5.2	5.5	5.7	6.0	6.2	6.4
62	1.1	1.4	1.7	2.1	2.5	3.0	3.5	3.7	4.0	4.3	4.5	4.7	4.9	5.2	5.4	5.6	5.9	6.1	6.4	6.6
61	1.2	1.4	1.8	2.2	2.6	3.1	3.6	3.8	4.1	4.4	4.6	4.8	5.1	5.3	5.6	5.8	6.1	6.3	6.6	6.8
60	1.2	1.5	1.8	2.2	2.7	3.2	3.7	3.9	4.2	4.5	4.8	4.9	5.2	5.5	5.7	6.0	6.2	6.5	6.8	7.0
58	1.3	1.6	1.9	2.3	2.8	3.3	3.9	4.1	4.4	4.7	5.0	5.2	5.5	5.7	6.0	6.3	6.6	6.9	7.1	7.4
56	1.3	1.6	2.0	2.4	2.9	3.5	4.1	4.3	4.6	4.9	5.2	5.5	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8
54	1.4	1.7	2.1	2.5	3.0	3.6	4.3	4.5	4.8	5.2	5.5	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.2
52	1.4	1.8	2.2	2.6	3.2	3.8	4.5	4.7	5.0	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.9	8.2	8.5
50	1.5	1.9	2.3	2.7	3.4	4.0	4.6	4.9	5.2	5.6	5.9	6.3	6.6	6.9	7.3	7.6	7.9	8.2	8.6	8.9
48	1.6	1.9	2.4	2.9	3.5	4.1	4.8	5.1	5.4	5.8	6.2	6.5	6.9	7.2	7.5	7.9	8.2	8.6	8.9	9.3
46	1.6	2.0	2.5	3.0	3.6	4.3	5.0	5.3	5.7	6.1	6.5	6.8	7.2	7.5	7.8	8.2	8.6	8.9	9.3	9.7
44	1.7	2.1	2.6	3.1	3.8	4.4	5.2	5.5	5.9	6.3	6.7	7.1	7.4	7.8	8.2	8.5	8.9	9.3	9.7	10.1
42	1.7	2.2	2.7	3.2	3.9	4.6	5.4	5.7	6.1	6.5	6.9	7.4	7.7	8.1	8.5	8.9	9.3	9.7	10.0	10.5
40	1.8	2.2	2.8	3.3	4.0	4.8	5.6	5.9	6.3	6.7	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0	10.4	10.9
38	1.9	2.3	2.8	3.4	4.2	4.9	5.8	6.1	6.6	7.0	7.4	7.9	8.3	8.7	9.1	9.5	9.9	10.4	10.8	11.3
36	1.9	2.4	2.9	3.6	4.3	5.1	6.0	6.4	6.8	7.2	7.7	8.1	8.6	9.0	9.4	9.9	10.3	10.8	11.2	11.1
34	2.0	2.5	3.0	3.7	4.5	5.3	6.2	6.6	7.0	7.4	7.9	8.4	8.9	9.3	9.7	10.2	10.7	11.1	11.6	12.5
32	2.0	2.5	3.1	3.8	4.6	5.4	6.4	6.8	7.2	7.7	8.2	8.7	9.2	9.6	10.1	10.5	11.1	11.5	12.0	12.7
30	2.1	2.6	3.2	3.9	4.7	5.6	6.6	7.0	7.4	7.9	8.4	8.9	9.5	9.9	10.4	10.9	11.4	11.9	12.4	12.9
28	2.2	2.7	3.3	4.0	4.9	5.7	6.8	7.2	7.7	8.2	8.7	9.2	9.7	10.2	10.7	11.2	11.8	12.3	12.8	13.3
26	2.2	2.8	3.4	4.1	5.0	5.9	6.9	7.4	7.9	8.4	8.9	9.5	10.0	10.6	11.1	11.6	12.1	12.6	13.2	13.8
24	2.3	2.9	3.5	4.3	5.1	6.1	7.1	7.6	8.1	8.6	9.2	9.8	10.3	10.9	11.4	11.9	12.5	13.0	13.6	14.2
22	2.3	2.9	3.6	4.4	5.3	6.3	7.4	7.8	8.4	8.9	9.4	10.0	10.6	11.2	11.7	12.3	12.8	13.4	14.0	14.6
20	2.4	3.0	3.7	4.5	5.4	6.5	7.6	8.1	8.6	9.2	9.7	10.2	10.9	11.5	12.1	12.6	13.2	13.8	14.4	15.0
18	2.5	3.1	3.8	4.6	5.6	6.6	7.8	8.3	8.8	9.4	9.9	10.5	11.2	11.8	12.4	12.9	13.6	14.2	14.8	15.5
16	2.5	3.2	3.9	4.7	5.7	6.8	8.0	8.5	9.1	9.6	10.2	10.8	11.5	12.1	12.7	13.3	13.9	14.6	15.2	15.9
14	2.6	3.2	4.0	4.8	5.8	7.0	8.2	8.7	9.3	9.8	10.5	11.1	11.8	12.4	13.0	13.7	14.3	15.0	15.6	16.4
12	2.6	3.3	4.1	4.9	6.0	7.1	8.4	8.9	9.5	10.1	10.8	11.3	12.1	12.7	13.4	14.1	14.7	15.4	16.1	16.8
10	2.7	3.4	4.2	5.1	6.1	7.3	8.6	9.2	9.7	10.4	11.0	11.6	12.3	13.0	13.7	14.4	15.1	15.8	16.5	17.2
8	2.8	3.5	4.3	5.2	6.2	7.5	8.8	9.4	9.9	10.6	11.3	11.9	12.6	13.3	14.1	14.7	15.5	16.2	16.9	17.7
6	2.8	3.5	4.4	5.3	6.4	7.6	9.0	9.6	10.2	10.8	11.5	12.2	12.9	13.6	14.4	15.1	15.8	16.6	17.4	18.1
4	2.9	3.6	4.5	5.4	6.5	7.8	9.2	9.8	10.4	11.1	11.8	12.5	13.2	13.9	14.7	15.5	16.3	17.0	17.8	18.6
2	3.0	3.7	4.5	5.5	6.7	7.9	9.4	10.0	10.7	11.4	12.0	12.8	13.5	14.3	15.1	15.8	16.6	17.4	18.3	19.0

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[a] Copyright, 1929, Parks-Cramer Co.

TABLE I.—(*Continued*).

Relative Humidity, per cent	Dry Bulb Temperature, deg. Fahr.																	
	58	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
	WET BULB DEPRESSION																	
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
96	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9
94	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3
92	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8
90	1.7	1.8	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
88	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.5	2.6	2.6	2.6	2.7	2.7
86	2.4	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.1	3.2
84	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.5	3.6	3.6
82	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	3.7	3.8	3.8	3.8	3.9	3.9	4.0	4.1	4.1
80	3.5	3.6	3.7	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.4	4.5	4.5	4.6
79	3.7	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.4	4.5	4.6	4.7	4.7	4.8	4.8
78	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.9	4.9	5.0	5.1
77	4.1	4.2	4.3	4.3	4.4	4.5	4.6	4.6	4.7	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.2	5.3
76	4.3	4.4	4.5	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.5	5.6
75	4.4	4.6	4.7	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.7	5.7	5.8
74	4.6	4.8	4.9	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.7	5.7	5.8	5.9	6.0	6.1
73	4.8	5.0	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.6	5.7	5.8	5.9	6.0	6.1	6.1	6.2	6.3
72	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6
71	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.5	6.6	6.7	6.8
70	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1
69	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3
68	5.8	5.9	6.0	6.1	6.2	6.3	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6
67	5.9	6.1	6.2	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8
66	6.1	6.3	6.4	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.5	7.6	7.7	7.8	7.9	8.0	8.1
65	6.3	6.5	6.6	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.7	7.8	7.9	8.0	8.1	8.2	8.3
64	6.5	6.7	6.8	7.0	7.1	7.2	7.3	7.4	7.6	7.7	7.8	7.9	8.0	8.1	8.3	8.4	8.5	8.6
63	6.7	6.9	7.0	7.2	7.3	7.4	7.6	7.7	7.8	7.9	8.0	8.2	8.3	8.4	8.5	8.6	8.7	8.9
62	6.9	7.1	7.3	7.4	7.5	7.6	7.8	7.9	8.0	8.1	8.3	8.4	8.5	8.6	8.8	8.9	9.0	9.1
61	7.1	7.3	7.5	7.6	7.7	7.9	8.0	8.1	8.2	8.4	8.5	8.6	8.7	8.9	9.0	9.1	9.3	9.4
60	7.3	7.5	7.7	7.8	8.0	8.1	8.2	8.3	8.5	8.6	8.7	8.9	9.0	9.1	9.3	9.4	9.5	9.7
58	7.7	7.9	8.1	8.2	8.4	8.5	8.7	8.8	8.9	9.1	9.2	9.4	9.5	9.6	9.8	9.9	10.1	10.2
56	8.1	8.4	8.5	8.7	8.8	8.9	9.1	9.2	9.4	9.6	9.7	9.9	10.0	10.2	10.3	10.5	10.6	10.8
54	8.5	8.8	8.9	9.1	9.3	9.4	9.6	9.7	9.9	10.0	10.2	10.4	10.5	10.7	10.8	11.0	11.2	11.3
52	8.8	9.2	9.4	9.5	9.7	9.8	10.0	10.2	10.4	10.5	10.7	10.9	11.0	11.2	11.4	11.5	11.7	11.8
50	9.2	9.6	9.8	10.0	10.2	10.3	10.5	10.7	10.8	11.0	11.2	11.4	11.5	11.7	11.9	12.1	12.3	12.4
48	9.6	10.0	10.2	10.4	10.6	10.7	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0
46	10.0	10.5	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6
44	10.5	10.9	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.7	12.9	13.1	13.3	13.6	13.8	14.0	14.2
42	10.9	11.3	11.5	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.9	14.1	14.3	14.5	14.8
40	11.3	11.8	12.0	12.2	12.4	12.7	12.9	13.1	13.3	13.6	13.8	14.0	14.2	14.4	14.7	14.9	15.1	15.4
38	11.7	12.2	12.5	12.7	12.9	13.1	13.3	13.6	13.8	14.1	14.3	14.5	14.8	15.0	15.2	15.5	15.7	16.0
36	12.2	12.7	12.9	13.1	13.4	13.6	13.8	14.1	14.3	14.6	14.8	15.1	15.3	15.6	15.8	16.1	16.3	16.6
34	12.6	13.1	13.3	13.6	13.8	14.1	14.3	14.6	14.8	15.1	15.4	15.6	15.9	16.1	16.4	16.7	16.9	17.2
32	13.0	13.5	13.8	14.1	14.3	14.6	14.9	15.1	15.4	15.7	15.9	16.2	16.5	16.7	17.0	17.3	17.5	17.8
30	13.4	14.0	14.3	14.5	14.8	15.1	15.4	15.6	15.9	16.2	16.5	16.8	17.0	17.3	17.6	17.9	18.1	18.4
28	13.9	14.5	14.7	15.0	15.3	15.6	15.9	16.2	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1
26	14.4	14.9	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1	19.4	19.8
24	14.8	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.2	18.5	18.8	19.1	19.4	19.8	20.1	20.4
22	15.2	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.1	18.4	18.8	19.1	19.4	19.7	20.1	20.4	20.7	21.1
20	15.7	16.4	16.7	17.0	17.3	17.7	18.0	18.3	18.7	19.0	19.3	19.7	20.0	20.4	20.7	21.1	21.4	21.8
18	16.1	16.8	17.2	17.5	17.8	18.2	18.5	18.9	19.2	19.6	19.9	20.3	20.6	21.0	21.4	21.7	22.1	22.5
16	16.6	17.3	17.7	18.0	18.3	18.7	19.0	19.4	19.8	20.2	20.5	20.9	21.3	21.6	22.0	22.4	22.8	23.2
14	17.0	17.8	18.1	18.5	18.9	19.2	19.6	20.0	20.4	20.7	21.1	21.5	21.9	22.3	22.6	23.0	23.4	23.9
12	17.5	18.2	18.6	19.0	19.4	19.8	20.2	20.6	21.0	21.3	21.7	22.1	22.5	22.9	23.3	23.7	24.1	24.6
10	18.0	18.7	19.1	19.5	19.9	20.3	20.7	21.1	21.5	22.0	22.4	22.8	23.2	23.6	24.0	24.4	24.8	25.3
8	18.5	19.2	19.6	20.0	20.5	20.9	21.3	21.7	22.1	22.6	23.0	23.4	23.8	24.3	24.7	25.1	25.6	26.0
6	19.0	19.8	20.2	20.6	21.0	21.4	21.8	22.2	22.7	23.2	23.6	24.0	24.5	25.0	25.4	25.8	26.3	26.8
4	19.4	20.3	20.7	21.1	21.6	22.0	22.4	22.9	23.3	23.8	24.2	24.7	25.2	25.6	26.1	26.6	27.0	27.5
2	19.9	20.8	21.2	21.7	22.1	22.6	23.0	23.5	24.0	24.4	24.9	25.4	25.9	26.3	26.8	27.3	27.8	28.3

TABLE I.—(*Continued*).

Relative Humidity, per cent	Dry Bulb Temperature, deg. Fahr.																	
	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
	WET BULB DEPRESSION																	
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
96	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1
94	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
92	1.8	1.8	1.9	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.2
90	2.2	2.3	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.6	2.7	2.7	2.7
88	2.7	2.8	2.8	2.8	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3
86	3.2	3.2	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5	3.6	3.6	3.7	3.7	3.7	3.8	3.8	3.9
84	3.7	3.7	3.8	3.8	3.9	3.9	4.0	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.3	4.4	4.4
82	4.2	4.2	4.3	4.3	4.4	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0
80	4.7	4.7	4.8	4.8	4.9	5.0	5.0	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.6	5.6
79	4.9	5.0	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.4	5.5	5.6	5.6	5.7	5.7	5.8	5.9	5.9
78	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.6	5.7	5.8	5.9	5.9	6.0	6.0	6.1	6.2	6.2
77	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9	5.9	6.0	6.0	6.1	6.2	6.2	6.3	6.4	6.4	6.5
76	5.6	5.7	5.8	5.8	5.9	6.0	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.5	6.6	6.7	6.7	6.8
75	5.9	5.9	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.5	6.6	6.7	6.7	6.8	6.9	7.0	7.1	7.1
74	6.1	6.2	6.3	6.4	6.4	6.5	6.6	6.7	6.7	6.8	6.9	7.0	7.0	7.1	7.2	7.3	7.4	7.4
73	6.4	6.5	6.6	6.6	6.7	6.8	6.9	7.0	7.0	7.1	7.2	7.3	7.3	7.4	7.5	7.6	7.7	7.7
72	6.6	6.7	6.8	6.9	7.0	7.1	7.1	7.2	7.3	7.4	7.5	7.6	7.6	7.7	7.8	7.9	8.0	8.0
71	6.9	7.0	7.1	7.2	7.3	7.3	7.4	7.5	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.4
70	7.2	7.3	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.2	8.3	8.4	8.5	8.6	8.7
69	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.5	8.6	8.7	8.8	8.9	9.0
68	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.8	8.9	9.0	9.1	9.2	9.3
67	7.9	8.0	8.1	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6	9.6
66	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0
65	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3
64	8.7	8.8	8.9	9.1	9.2	9.3	9.4	9.5	9.6	9.7	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6
63	9.0	9.1	9.2	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.2	10.3	10.4	10.5	10.6	10.7	10.9	11.0
62	9.3	9.4	9.5	9.6	9.8	9.9	10.0	10.1	10.2	10.3	10.5	10.6	10.7	10.8	11.0	11.1	11.2	11.3
61	9.5	9.7	9.8	9.9	10.1	10.2	10.3	10.4	10.5	10.7	10.8	10.9	11.0	11.2	11.3	11.4	11.5	11.7
60	9.8	9.9	10.1	10.2	10.3	10.4	10.6	10.7	10.8	11.0	11.1	11.2	11.3	11.5	11.6	11.7	11.8	12.0
58	10.4	10.5	10.6	10.8	10.9	11.0	11.2	11.3	11.5	11.7	11.8	11.9	12.0	12.1	12.3	12.4	12.5	12.7
56	10.9	11.1	11.2	11.3	11.5	11.6	11.8	11.9	12.1	12.3	12.4	12.5	12.7	12.8	12.9	13.1	13.2	13.4
54	11.5	11.6	11.8	11.9	12.1	12.2	12.4	12.6	12.7	12.9	13.0	13.2	13.3	13.5	13.6	13.8	13.9	14.1
52	12.0	12.2	12.4	12.5	12.7	12.8	13.0	13.2	13.4	13.5	13.7	13.8	14.0	14.2	14.3	14.5	14.6	14.8
50	12.6	12.8	12.9	13.1	13.3	13.5	13.6	13.8	14.0	14.2	14.4	14.5	14.7	14.9	15.0	15.2	15.4	15.5
48	13.2	13.4	13.5	13.7	13.9	14.1	14.3	14.5	14.7	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.1	16.3
46	13.8	14.0	14.2	14.4	14.6	14.8	14.9	15.1	15.3	15.5	15.7	15.9	16.1	16.3	16.5	16.7	16.9	17.0
44	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	16.8	17.0	17.2	17.4	17.6	17.8
42	15.0	15.2	15.4	15.6	15.8	16.1	16.3	16.5	16.7	16.9	17.1	17.4	17.6	17.7	17.9	18.1	18.4	18.6
40	15.6	15.8	16.0	16.3	16.5	16.7	16.9	17.1	17.4	17.6	17.8	18.1	18.3	18.5	18.7	18.9	19.2	19.4
38	16.2	16.4	16.7	16.9	17.1	17.4	17.6	17.8	18.1	18.3	18.6	18.8	19.1	19.3	19.5	19.7	20.0	20.2
36	16.8	17.1	17.3	17.6	17.8	18.1	18.3	18.5	18.8	19.1	19.3	19.6	19.8	20.1	20.3	20.5	20.8	21.1
34	17.4	17.7	18.0	18.2	18.5	18.8	19.0	19.3	19.5	19.8	20.1	20.3	20.6	20.9	21.1	21.4	21.6	21.9
32	18.1	18.3	18.6	18.9	19.2	19.5	19.7	20.0	20.3	20.6	20.8	21.1	21.4	21.7	21.9	22.2	22.5	22.7
30	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.7	23.0	23.3	23.6
28	19.4	19.7	20.0	20.3	20.6	20.9	21.2	21.5	21.8	22.1	22.4	22.7	23.0	23.3	23.6	23.9	24.2	24.5
26	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.3	22.6	22.9	23.2	23.5	23.8	24.2	24.5	24.8	25.1	25.4
24	20.7	21.1	21.4	21.7	22.0	22.3	22.7	23.0	23.4	23.7	24.0	24.3	24.7	25.0	25.3	25.7	26.0	26.3
22	21.4	21.7	22.1	22.4	22.8	23.1	23.4	23.8	24.2	24.5	24.8	25.2	25.5	25.9	26.2	26.6	26.9	27.3
20	22.1	22.4	22.8	23.1	23.5	23.9	24.2	24.6	25.0	25.3	25.7	26.1	26.4	26.8	27.1	27.5	27.8	28.2
18	22.8	23.2	23.6	23.9	24.3	24.7	25.0	25.4	25.8	26.2	26.5	26.9	27.3	27.7	28.1	28.4	28.8	29.2
16	23.5	23.9	24.3	24.7	25.1	25.5	25.9	26.3	26.7	27.0	27.4	27.8	28.2	28.6	29.0	29.4	29.8	30.2
14	24.2	24.6	25.0	25.4	25.9	26.3	26.7	27.1	27.5	27.9	28.3	28.7	29.1	29.6	30.0	30.4	30.8	31.2
12	25.0	25.4	25.8	26.2	26.7	27.1	27.5	27.9	28.4	28.8	29.2	29.7	30.1	30.5	31.0	31.4	31.8	32.3
10	25.7	26.2	26.6	27.0	27.5	27.9	28.3	28.8	29.3	29.7	30.1	30.6	31.0	31.5	32.0	32.4	32.9	33.3
8	26.5	26.9	27.4	27.8	28.3	28.8	29.2	29.7	30.1	30.6	31.1	31.6	32.0	32.5	33.0	33.4	33.9	34.4
6	27.2	27.7	28.2	28.6	29.1	29.6	30.1	30.5	31.0	31.6	32.0	32.5	33.0	33.5	34.0	34.5	35.0	35.5
4	28.0	28.5	29.0	29.5	30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.6	35.1	35.6	36.1	36.7
2	28.8	29.3	29.8	30.3	30.8	31.4	31.9	32.4	33.0	33.5	34.0	34.5	35.1	35.6	36.2	36.7	37.3	37.9

TABLE I.—(*Continued.*)

Relative Humidity, per cent	Dry Bulb Temperature, deg. Fahr.																	
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
	WET BULB DEPRESSION																	
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
96	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
94	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9
92	2.2	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5
90	2.7	2.8	2.8	2.8	2.8	2.9	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.2
88	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.7	3.8	3.8	3.8
86	3.9	3.9	3.9	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.5
84	4.5	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4.9	4.9	5.0	5.0	5.1	5.1	5.1
82	5.1	5.1	5.2	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.7	5.7	5.7	5.8	5.8
80	5.7	5.7	5.8	5.8	5.9	5.9	6.0	6.0	6.1	6.1	6.2	6.2	6.3	6.3	6.4	6.4	6.5	6.5
79	6.0	6.0	6.1	6.1	6.2	6.2	6.3	6.4	6.4	6.5	6.5	6.6	6.6	6.7	6.7	6.8	6.8	6.9
78	6.3	6.3	6.4	6.4	6.5	6.5	6.6	6.7	6.7	6.8	6.8	6.9	7.0	7.0	7.1	7.1	7.2	7.2
77	6.6	6.6	6.7	6.8	6.8	6.9	6.9	7.0	7.1	7.1	7.2	7.2	7.3	7.4	7.4	7.5	7.5	7.6
76	6.9	6.9	7.0	7.1	7.1	7.2	7.3	7.3	7.4	7.5	7.5	7.6	7.6	7.7	7.8	7.8	7.9	7.9
75	7.2	7.3	7.3	7.4	7.5	7.5	7.6	7.7	7.7	7.8	7.9	7.9	8.0	8.1	8.1	8.2	8.2	8.3
74	7.5	7.6	7.6	7.7	7.8	7.9	7.9	8.0	8.1	8.1	8.2	8.3	8.3	8.4	8.5	8.5	8.6	8.7
73	7.8	7.9	8.0	8.0	8.1	8.2	8.3	8.3	8.4	8.5	8.6	8.6	8.7	8.8	8.8	8.9	9.0	9.1
72	8.1	8.2	8.3	8.4	8.4	8.5	8.6	8.7	8.8	8.8	8.9	9.0	9.1	9.1	9.2	9.3	9.4	9.4
71	8.5	8.5	8.6	8.7	8.8	8.9	8.9	9.0	9.1	9.2	9.3	9.3	9.4	9.5	9.6	9.6	9.7	9.8
70	8.8	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.4	9.5	9.6	9.7	9.8	9.9	9.9	10.0	10.1	10.2
69	9.1	9.2	9.3	9.4	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.1	10.2	10.3	10.4	10.5	10.6
68	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	10.9
67	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.1	11.2	11.3
66	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.3	11.4	11.5	11.6	11.7
65	10.4	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1
64	10.7	10.9	11.0	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.5
63	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9
62	11.4	11.5	11.6	11.8	11.9	12.0	12.1	12.2	12.3	12.4	12.6	12.7	12.8	12.9	13.0	13.1	13.2	13.3
61	11.8	11.9	12.0	12.1	12.2	12.4	12.5	12.6	12.7	12.8	12.9	13.1	13.2	13.3	13.4	13.5	13.6	13.7
60	12.1	12.2	12.4	12.5	12.6	12.7	12.8	13.0	13.1	13.2	13.3	13.4	13.6	13.7	13.8	13.9	14.0	14.1
58	12.8	12.9	13.1	13.2	13.3	13.5	13.6	13.7	13.9	14.0	14.1	14.2	14.4	14.5	14.6	14.7	14.8	15.0
56	13.5	13.7	13.8	13.9	14.1	14.2	14.3	14.5	14.6	14.8	14.9	15.0	15.2	15.3	15.4	15.6	15.7	15.8
54	14.2	14.4	14.5	14.7	14.8	15.0	15.1	15.3	15.4	15.6	15.7	15.9	16.0	16.1	16.3	16.4	16.6	16.7
52	15.0	15.1	15.3	15.5	15.6	15.8	15.9	16.1	16.2	16.4	16.5	16.7	16.8	17.0	17.1	17.3	17.4	17.6
50	15.7	15.9	16.0	16.2	16.4	16.6	16.7	16.9	17.0	17.2	17.4	17.5	17.7	17.9	18.0	18.2	18.3	18.5
48	16.5	16.6	16.8	17.0	17.2	17.4	17.5	17.7	17.9	18.0	18.2	18.4	18.6	18.8	18.9	19.1	19.2	19.4
46	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.7	18.9	19.1	19.3	19.5	19.7	19.8	20.0	20.2	20.3
44	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.6	20.7	20.9	21.1	21.3
42	18.8	19.0	19.2	19.5	19.7	19.9	20.1	20.3	20.5	20.7	20.9	21.1	21.3	21.5	21.7	21.9	22.1	22.3
40	19.6	19.8	20.1	20.3	20.5	20.7	20.9	21.2	21.4	21.6	21.8	22.0	22.2	22.5	22.7	22.9	23.1	23.3
38	20.4	20.7	20.9	21.1	21.4	21.6	21.8	22.1	22.3	22.5	22.7	23.0	23.2	23.4	23.7	23.9	24.1	24.3
36	21.3	21.5	21.8	22.0	22.3	22.5	22.7	23.0	23.2	23.5	23.7	23.9	24.2	24.4	24.7	24.9	25.1	25.4
34	22.2	22.4	22.6	22.9	23.2	23.4	23.7	23.9	24.2	24.4	24.7	24.9	25.2	25.4	25.7	25.9	26.2	26.4
32	23.0	23.3	23.5	23.8	24.1	24.4	24.6	24.9	25.2	25.4	25.7	26.0	26.2	26.5	26.7	27.0	27.3	27.5
30	23.9	24.2	24.5	24.7	25.0	25.3	25.6	25.9	26.2	26.4	26.7	27.0	27.3	27.6	27.8	28.1	28.4	28.7
28	24.8	25.1	25.4	25.7	26.0	26.3	26.6	26.9	27.2	27.5	27.8	28.0	28.4	28.6	28.9	29.2	29.5	29.8
26	25.7	26.0	26.3	26.6	27.0	27.3	27.6	27.9	28.2	28.5	28.8	29.1	29.5	29.8	30.1	30.4	30.7	31.0
24	26.7	27.0	27.3	27.6	28.0	28.3	28.6	28.9	29.3	29.6	29.9	30.3	30.6	30.9	31.2	31.6	31.9	32.2
22	27.6	28.0	28.3	28.6	29.0	29.3	29.7	30.0	30.4	30.7	31.1	31.4	31.8	32.1	32.4	32.8	33.1	33.5
20	28.6	28.9	29.3	29.7	30.0	30.4	30.8	31.1	31.5	31.9	32.2	32.6	32.9	33.3	33.7	34.0	34.4	34.7
18	29.6	29.9	30.3	30.7	31.1	31.5	31.9	32.2	32.6	33.0	33.4	33.8	34.2	34.5	34.9	35.3	35.7	36.0
16	30.6	31.0	31.4	31.8	32.2	32.6	33.0	33.4	33.8	34.2	34.6	35.0	35.4	35.8	36.2	36.6	37.0	37.4
14	31.6	32.1	32.5	32.9	33.3	33.7	34.2	34.6	35.0	35.4	35.9	36.3	36.7	37.1	37.5	38.0	38.4	38.8
12	32.7	33.2	33.6	34.0	34.5	34.9	35.4	35.8	36.2	36.7	37.1	37.6	38.0	38.5	38.9	39.4	39.8	40.3
10	33.8	34.3	34.7	35.2	35.6	36.1	36.6	37.1	37.5	38.0	38.4	38.9	39.4	39.9	40.3	40.8	41.3	41.8
8	34.9	35.4	35.9	36.4	36.8	37.3	37.8	38.3	38.8	39.3	39.8	40.3	40.8	41.3	41.8	42.3	42.8	43.3
6	36.0	36.5	37.0	37.6	38.1	38.6	39.1	39.6	40.1	40.7	41.2	41.7	42.2	42.8	43.3	43.8	44.3	44.9
4	37.2	37.7	38.2	38.8	39.3	39.9	40.4	41.0	41.5	42.1	42.6	43.2	43.7	44.3	44.8	45.4	45.9	46.5
2	38.4	38.9	39.5	40.1	40.6	41.2	41.8	42.3	42.9	43.5	44.1	44.7	45.2	45.8	46.4	47.0	47.6	48.2

The most suitable table is one which requires a minimum of interpolation and which can give results to the nearest 1 per cent of relative humidity when the psychrometric observations are sufficiently accurate. For information and convenience there has been included, by special permission, Table I, a psychrometric relative humidity table which combines both accuracy and convenience to an exceptional degree.

The method of constructing Table I was as follows:

1. A working tabulation was first made up showing vapor pressures corresponding to the various dry-bulb temperatures and relative humidities. The pressures corresponding to 100-per-cent relative humidity were copied directly from the table of saturated vapor pressure in Smithsonian Meteorological Tables.[1] Values for relative humidities other than 100 per cent were computed from these by direct proportion.
2. Reference was then made to the Smithsonian table entitled, "Reduction of Psychrometric Observations," which lists vapor pressures (as computed by the formula 1 above) against temperatures and wet bulb depressions and from which, by interpolation, wet bulb depressions corresponding to the various dry bulb temperatures and relative humidities were ascertained.

Examples in Use of Table I:

(*a*) Given the following readings of the sling psychrometer: dry bulb 73° F., wet bulb 60° F., what is the relative humidity?

Subtracting the dry and wet bulb temperatures gives 13° F. as the wet bulb depression. Find 73° F., dry bulb temperature, in the row of figures across the top of Table I. Follow down this column to 13.0° F., wet bulb depression. Follow horizontally to the left and find 46 per cent, which is the relative humidity.

(*b*) Given the following readings of the sling psychrometer: dry bulb 79¾° F., wet bulb 71½° F., what is the relative humidity?

Subtracting the dry and wet bulb temperatures gives 8¼° F. as the wet bulb depression. In this case use the column headed by 80° F., dry bulb temperature. Follow down this column to 8.3° F., wet bulb depression and then to the left and find 67 per cent, which is the relative humidity.

(*c*) What wet bulb depression must be maintained in order to maintain a relative humidity of 65 per cent at 70° F.?

In that part of Table I containing a dry bulb temperature of 70° F., find 65 per cent in the left-hand column and then follow horizontally to the right to the column headed by 70° F. The figure at the intersection is 7.7° F. which is the required wet bulb depression.

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[1] See Table 75 of the *Smithsonian Meteorological Tables*, Smithsonian Inst., Washington, D. C., 4th revised edition, 1924.

REPORT OF COMMITTEE D-15
ON
THERMOMETERS

Committee D-15 on Thermometers prepared, in 1924, specifications for a high-distillation thermometer which have since been incorporated in the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 – 30) under jurisdiction of Committee D-2 on Petroleum Products and Lubricants; Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 30) under jurisdiction of Committee D-4 on Road and Paving Materials; and Standard Method of Test for Distillation of Creosote Oil (D 246 – 30) under jurisdiction of Committee D-7 on Timber.

During the past year, it has been called to the attention of the committee that under some test conditions the bulb of the high-distillation thermometer may be heated to a point that will impair the accuracy of the instrument and throw such accuracy beyond the tolerance permitted by the specification. The overheating may be greater than shown by the indicated temperature for the reason that the thermometer is calibrated for total immersion and in all the tests enumerated it is used under partial-immersion conditions. The committee has given very careful consideration to the various suggestions offered for overcoming this criticism, and recommends that the following Note be added to the specifications for the high-distillation thermometer in those standards in which it appears:

> NOTE.—Under certain test conditions, the bulb of the thermometer may be 50° F. (28° C.) above the temperature indicated by the thermometer and at an indicated temperature of 700° F. (371° C.) the temperature of the bulb is approaching a critical range in the glass. It is therefore desirable not to use this thermometer under such conditions at indicated temperatures above 700° F. (371° C.) without checking the ice-point.

This report has been submitted to letter ballot of the committee, which consists of 11 members; 8 members returned their ballots all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

C. S. REEVE,
Secretary.

REPORT OF COMMITTEE D-16
ON
SLATE

The activities of the committee during the past year have been centered upon perfecting tentative methods of tests for water absorption of slate and for flexural strength through its Subcommittee I on Methods of Tests, and to developing methods of determining weathering characteristics through its Subcommittee V on Weathering Characteristics and Subcommittee IX on Utilization and Performance. Considerable progress has been made in these directions and also in improvements in the quarrying of slate and milling processes which have been put into use by various producers through cooperation with Subcommittee III on Machining and Workability. The results of the first mentioned activities are shown by the proposed changes given later in the report to the Tentative Method of Test for Water Absorption of Slate (D 221 - 27 T) and the Tentative Methods of Flexure Testing of Slate (Determination of Modulus of Rupture and Modulus of Elasticity) (D 222 - 27 T) and the advancement of each to a standard of the Society. The results of letter ballots are included in this report and the amendments are appended thereto.

Regarding determination of weathering characteristics, the work of Subcommittee V has been continued as well as other investigations at the U. S. Bureau of Standards in collaboration with this and other subcommittees including also individual members who have served in their capacities as members of a committee of the Federal Specifications Board charged with the preparation of specifications for roofing slate.

Committee D-16 held three meetings during the year, one each as usual in connection with the annual meeting of the Society and with the annual meeting of the National Slate Association. The other was held at Sky Top, Pa., with visits to some of the Pennsylvania quarries and mills and to Lafayette College. At two of these regular meetings, the committee went into session as a committee of the whole and with other slate producers and technicians discussed tests and conclusions as arrived at to date and embodied as provisions incorporated in drafts of specifications for roofing slate submitted to Committee D-16 and the entire slate industry by the committee of the Federal Specifications Board. The results of these deliberations will appear in due course as Federal Specifications for Roofing Slate, the essentials of which it is hoped can next year be combined with the recommendations contained in last year's report of this committee and offered by Committee D-16 as a tentative method for determining the characteristics of roofing slate. The cooperation referred to from producers in improving quarrying and milling methods will be found included among the activities of subcommittees.

The membership of the committee has been increased during the year by the addition of one general interest and one producer member. Mr. H. S. Brightly has also been added as a representative of Committee D-18 on Natural Building Stones, to which committee Mr. W. A. Kitto has been assigned as a representative of Committee D-16.

RECOMMENDATIONS AFFECTING TENTATIVE STANDARDS

The committee recommends that the following two tentative methods be revised and advanced to standard. The revisions are referred to under the subcommittee responsible and the proposed revised specifications are appended hereto:[1]

Tentative Method of Test for Water Absorption of Slate (D 221 - 27 T),[2] as recommended by Subcommittee I;

Tentative Methods of Flexure Testing of Slate (Determination of Modulus of Rupture and Modulus of Elasticity (D 222 - 27 T),[2] as recommended by Subcommittee I and referred to also under Subcommittee X.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Tentative Method of Test for Water Absorption of Slate (D 221 - 27 T), as revised	18	0	4
Tentative Methods of Flexure Testing of Slate (Determination of Modulus of Rupture and Modulus of Elasticity) (D 222 - 27 T), as revised	21	0	0

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Methods of Tests (D. W. Kessler, chairman).—A cooperative study of five testing laboratories to study various conditions affecting the absorption results of slate was outlined in the 1930 report[3] of Committee D-16. This work has been completed and the results are shown in Table I, and in Figs. 1 and 2.

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[1] See 1931 Supplement to Book of A.S.T.M. Standards, pp. 98 and 100, respectively.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, pp. 972 and 974, respectively (1927); also 1930 Book of A.S.T.M. Tentative Standards, pp. 518 and 520, respectively.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 882 (1930).

It will be seen that each laboratory was supplied with seven samples of slate. Samples CR and CS represent two grades of slate from the same quarry, A_2 and A_4 samples from the same region while the three other samples were from widely separated regions. Each sample consisted of thirty slags, 6-in. square by $\frac{1}{4}$-in. thick, cut from the same piece of slate and all finished to smooth surfaces on a rubbing bed. Each laboratory was supplied with six slabs of each sample.

One object was to find if it is feasible to dry slate at some temperature below the boiling point of water. Each laboratory divided the specimens of each sample into two groups and used one for drying experiments. The average results obtained for each sample by the five laboratories are shown by the five sets of curves in Figs. 1 and 2.

TABLE I.—ABSORPTION PERCENTAGES OBTAINED BY DRYING BEFORE IMMERSION AND BY IMMERSION BEFORE DRYING.

Slate Sample	Laboratory No. 1		Laboratory No. 2		Laboratory No. 3	Laboratory No. 4		Laboratory No. 5	
	48-hour Absorption		48-hour Absorption		48-hour Absorption	48-hour Absorption		48-hour Absorption	
	Dried First[a]	Soaked First[b]	Dried First[c]	Soaked First[d]	Dried First[e]	Dried First[f]	Soaked First[d]	Dried First[f]	Soaked First[g]
M	0.04	0.07	0.06	0.05	0.05	0.06	0.16	0.04	0.05
V	0.16	0.18	0.15	0.17	0.15	0.17	0.15	0.15	0.20
CR	0.23	0.17	0.11	0.15	....	0.22	....	0.11	0.15
CS	0.10	0.21	0.11	0.13	0.11	0.14	0.19	0.12	0.14
A_4	0.26	0.27	0.23	0.22	....	0.24	....	0.21	0.30
A_2	0.28	0.28	0.24	0.26	....	0.29	....	0.24	0.28
BC	0.32	0.30	0.30	0.32	0.27	0.30	0.35	0.33	0.34

[a] Dried 11 days at temperature from 120 to 220° F.

[b] Dried 2 days at 220° F.

[c] Dried 5 days at temperature from 120 to 150° F.

[d] Dried 2 days at 150° F.

[e] Dried 2 days at 150° F.

[f] Dried 7 days at temperature from 120 to 185° F.

[g] Dried 1 day at 230° F.

A casual observation will show that slate is a slowly drying material and that several days is required to produce a constant weight if temperatures below 212° F. are used. A notable feature of the results is the indicated difference in the original moisture content of the specimens. For instance, laboratory No. 2 found a variation of from 0.03 to 0.16 per cent while laboratory No. 1 found the range for the same materials to be between 0.02 and 0.06 per cent. This is probably due to the natural drying of the samples before testing was started. A peculiar feature is shown by the results of laboratory No. 4 where some of the samples showed rather large increases in weight at times during the drying. This may have been due to leaving the specimens out in the open air too long before weighing.

Approximately the same order is shown for the samples by laboratories Nos. 1, 2 and 3, with sample M at the bottom, and samples

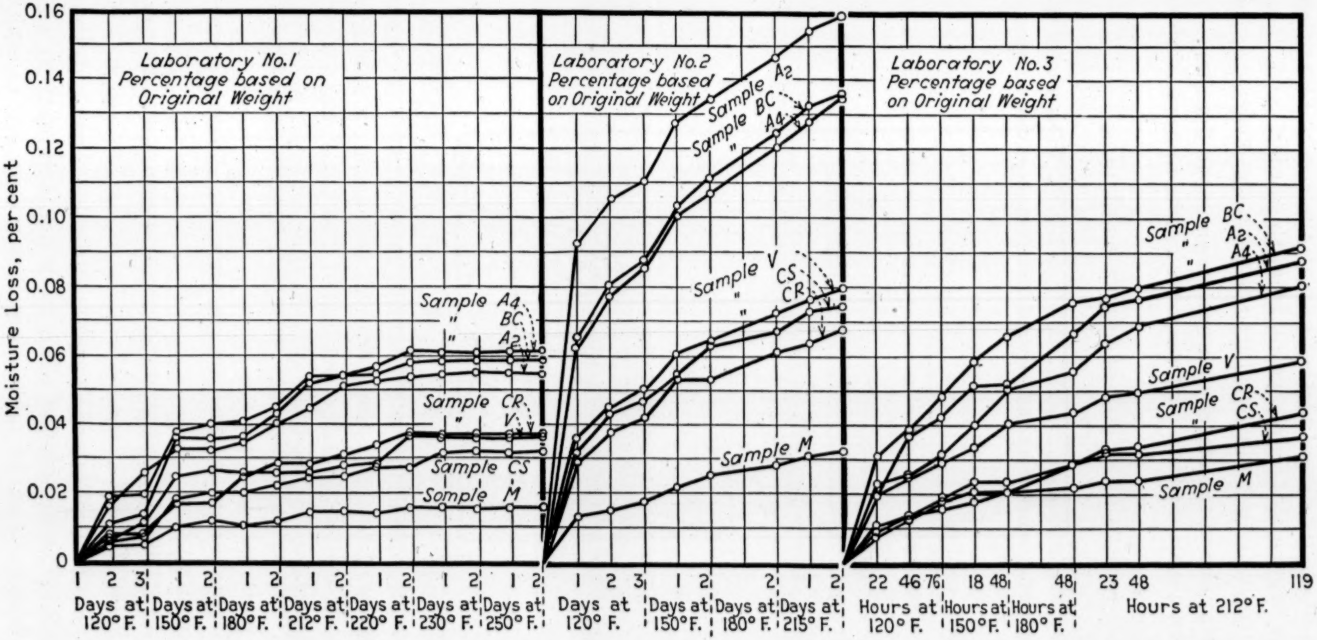

FIG. 1.—Drying Rates Obtained by Testing Laboratories on Seven Different Slates and Absorption Percentages Obtained by Two Test Procedures.

A_2, A_4 and BC fairly close together and at the top. The other two laboratories show a marked variation from this order.

Factors which may influence these divergencies may be as follows:

1. Variations in the slate from one specimen to another;
2. Open cleavage planes or transverse cracks in some of the specimens;
3. Oven ventilation or lack of proper ventilation;

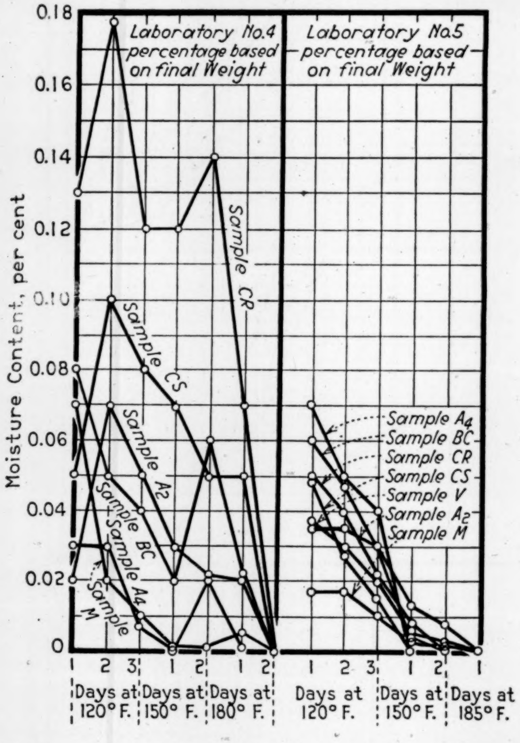

FIG. 2.—Drying Rates Obtained by Testing Laboratories on Seven Different Slates and Absorption Percentages Obtained by Two Test Procedures.

4. Drying alongside of other materials containing a considerable amount of moisture;
5. Absorption of moisture from the air when allowed to stand too long after cooling; and
6. By upsetting the equilibrium of the balance due to weighing specimens while still hot.

A tabulation of absorption variations has been made to show the usual variations in samples of slate from one specimen to another. The table below shows the variation for 26 samples in which the number of specimens tested varied from two to eight for each slate sample. The last column shows the difference between the highest and lowest absorption results on specimens of each sample. Slates of low absorption naturally show the smallest difference between different specimens and *vice versa.* The lowest variation shown for any slate is 0.02 per cent and the highest is 0.36 per cent. The average variation for all is 0.076 per cent, while a majority show variations of 0.05 per cent or more. Since the specimens of each sample were tested in as nearly the same manner as is practical under laboratory conditions, these results should have considerable value in showing what variations must be expected in the slate.

SLATE SAMPLE	LABORATORY	NUMBER OF SPECIMENS TESTED	MAXIMUM VARIATION, PER CENT
a	No. 607	4	0.13
b	No. 608	6	0.05
c	No. 609	2	0.07
d	No. 620	4	0.03
e	No. 669	3	0.04
f	No. 670	5	0.03
g	No. 671	6	0.07
h	No. 712	8	0.02
i	No. 739	9	0.13
j	No. 740	8	0.11
k	No. 772	8	0.05
l	No. 773	8	0.04
m	No. 774	8	0.04
n	No. 775	8	0.11
o	No. 776	6	0.05
p	No. 777	8	0.06
q	No. 778	4	0.05
r	No. 779	8	0.04
s	No. 780	8	0.03
t	No. 781	8	0.03
u	No. 782	7	0.36
v	No. 783	7	0.11
w	No. 784	7	0.28
x	No. 785	8	0.02
y	No. 786	8	0.08
z	No. 787	7	0.05

Average variation of all specimens tested....................0.076 per cent.

For instance, each set of specimens was dried at the same time in the same oven. The cooling period and immersion period could not have varied more than 10 minutes and the same operator conducted the tests. It appears from this table that the variation in slate would account for a large part of the difference obtained in the drying tests by the five laboratories.

Lower drying temperatures were thought to be desirable because evidence was found that higher temperatures injured slate. The work described above indicates that the use of a low drying temperature would require a considerable increase in the drying period which is undesirable. In view of this, consideration has been given to reversing the absorption test procedure and obtaining the wet weight first. Table I shows the results obtained by the five laboratories on the same samples by (*a*) drying first and (*b*) soaking first.

The results of the drying-first procedure were obtained on the specimens subjected to the prolonged drying periods indicated by the curves and the soaking-first results were obtained on the other half of the specimens of the same samples. The agreement between the two methods is good in most cases but it will be seen that slightly higher results are obtained by soaking the specimens first and drying afterwards. This procedure eliminates any possible effects of heat on the slate and permits the use of a temperature that will give the desired drying in one day.

The subcommittee recommends that the Tentative Method of Test for Water Absorption of Slate (D 221 - 27 T) be revised as appended hereto[1] and advanced to standard.

At the suggestion of Mr. M. O. Fuller as to the possibility of developing information on slate through the use of X-rays, this subject was referred to Subcommittee I for further consideration.

Subcommittee III on Machining and Workability (Oliver Bowles, chairman).—While the slate industry has been passing through difficult times, it is encouraging to note that more than usual attention is being given to improvement in processes. The wire saw is recognized as essential equipment in the Pennsylvania quarries. Its use in other districts is contemplated and will prove to be of great advantage when given a fair trial.

The Monson Maine Slate Co. has made remarkable progress in the use of drum sanders for finishing electrical slate. The Chapman Slate Co. has had a large diamond saw in operation for nearly a year sawing blocks for roofing slate manufacture. While it has proved quite satisfactory, sufficient experience has not yet been gained to decide certain points, such as the best saw diameter (whether 60 or 84 in.), the proper blade thickness, and the best sawing speed. Additional data will be accumulated during the coming year.

The Keenan Structural Slate Co. has installed a 3 ft.-6 in. Allen sand cone and a 6-ft. slime cone. Improved methods are used by Parsons Brothers Slate Co. with respect to the washing of grit and various problems encountered. F. C. Sheldon Co. has had successful results with the introduction of "gang saws."

Little progress has been made in the use of saws having tungsten-carbide-tipped teeth. The saws will undoubtedly cut much faster than those having steel teeth, but the high cost of this new alloy discourages its use.

Several important considerations in machining and workability have been presented for consideration by the committee by W. S. Mershon. Briefly, the following improvements in process were presented for consideration:

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[1] See 1931 Supplement to Book of A.S.T.M. Standards, p. 98.

1. To substitute wire sawing for splitting on the bed in the manufacture of structural slate;

2. To use the wire saw extensively in the mill to take the place of circular saws, planers and possibly rubbing beds;

3. To cut and trim blocks to more exact sizes in the quarry.

The following comments on these points are offered:

1. The slaty cleavage is the outstanding characteristic of slate. Without this property the manufacture of roofing slate would be impossible. Can it be entirely disregarded in the mill? It is generally agreed that blackboards could not be sawed to the desired thickness as cheaply as they can be split, since there seems to be an adequate supply of free-splitting and straight-splitting soft slate to satisfy all market demands for this product. For the manufacture of structural slate the advantage of using the cleavage is not so definite. In general, it may be stated that the natural directions of cleavage are widely utilized in the manufacture of stone products. It would seem that the cost of sawing is the important factor. In a straight-splitting slate splitting is the usual way, and smoothing with a planer or by other means would be much cheaper than sawing. In slate with a crooked split, wire sawing might be of advantage.

2. The wire saw should be extensively used in mill operations. There are some mechanical problems to be solved. Wire sawing of mill blocks should be much cheaper than cutting with circular saws and would give smoother surfaces. As to the accuracy of sawing, there is some doubt. To cut with a wire to accurate size with a tolerance of $\frac{1}{16}$ in. may not be attained without some difficulty. Vibration of the wire may widen the cut, and the wearing of the wire may affect the adjustment. Also there is a tendency for a wire meeting a harder mass to be diverted from its true course. In cutting structural slate at a long angle to a hard ribbon the wire might be diverted in this way. For short cuts the trouble might not be serious. If such mechanical difficulties can be overcome, there is no reason why the wire should not be employed to take the place of circular saws, planers, and rubbing beds except in straight-splitting and easy-splitting slates. Even in the latter the wire saw could be used to advantage in making cross cuts.

3. In other types of stone the size of the primary block in the quarry is usually governed by the size of the finished product. The slate quarryman, however, cannot plan his cuts with mathematical precision for he encounters ribbons and seams that govern the size and shape of his blocks to some extent. Since the use of the wire saw

has become general in Pennsylvania, there has been a more definite trend toward the production of uniform and regular blocks. Much profitable study could be given to the regulation of quarry cuts to conform more closely with the sizes of the finished blocks.

Subcommittee V on Weathering Characteristics (C. H. Behre, chairman).—This subcommittee has little that is new to report. Some correlation is being attempted between work on building stones in general and work on slate, from the weathering point of view, care being taken, however, to make no comparisons between different materials so far as wear and durability are concerned. The object is to see whether or not tests similar to those applied to other building materials can successfully be applied to slate. This is covered in a joint paper by G. F. Loughlin and C. H. Behre, Jr., presented in connection with the Symposium on Weathering Characteristics of Masonry Materials being held in conjunction with the annual meeting of the Society.

Chemical weathering of slate has been carried out with test blocks, as reported in the 1930 Report of Committee D-16.[1] These blocks are to be examined with the aid of the microscope, but the examination has not yet been conducted.

Subcommittee IX on Utilization and Performance (R. S. Tibbals, chairman).—This subcommittee reports progress in view of the special presentation of the Specification for Roofing Slate by the representatives of the Federal Specifications Board who are also members of Committee D-16 and the discussion by members of Committee D-16 and producers, not members, who were present at two meetings of the committee.

Mr. J. W. Ginder presided over these meetings during the discussions of these specifications and stated that since the proposed Specification for Roofing Slate had been distributed, a subcommittee of the Federal Specifications Board had been appointed to work out the details of the specification. This committee consisted of Messrs. Bowles, Kessler and Stacey, which committee after discussion summed up for the Federal Specifications Board, as a result of which the following motion was unanimously carried: "That, it is the sense of this joint conference that the Proposed Federal Specification for Roofing Slate as outlined and amended at this meeting by Mr. J. W. Ginder and his subcommittee be approved by the producers and Committee D-16 members present and referred back for the further usual procedure of the Federal Specifications Board."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 884 (1930).

Subcommittee X on Standardization of Samples (D. W. McDougall, chairman).—Reference is made to the interesting and suggestive recommendations of this committee printed in last year's report, some of which will be found incorporated in the revised Tentative Methods of Water Absorption of Slate (D 221 - 27 T) and Flexure Testing of Slate (D 222 - 27 T) as voted upon for advancement to standard as appended hereto.[1]

This report has been submitted to letter ballot of the committee, which consists of 24 members; 21 members returned their ballots, of whom 20 have voted affirmatively and none negatively.

Respectfully submitted on behalf of the committee,

WILLIAM B. PLANK,
Chairman.

D. KNICKERBACKER BOYD,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Test for Water Absorption of Slate, and of Flexure Testing of Slate (Determination of Modulus of Rupture and Modulus of Elasticity) were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1931, and appear in the 1931 Supplement to Book of A.S.T.M. Standards, pages 98 and 100, respectively.

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[1] See 1931 Supplement to Book of A.S.T.M. Standards, pp. 98 and 100, respectively.

REPORT OF COMMITTEE D-18
ON
NATURAL BUILDING STONES

Committee D-18 on Natural Building Stones held one meeting during the past year. The committee is able to report definite progress on its program by reason of the work done by its several subcommittees and acted upon at that meeting.

There have been several changes in the personnel of Committee D-18 during the year. The resignations of H. C. Peffer and C. R. Yanson were accepted. The appointment made by Committee D-16 on Slate of W. A. Kitto to serve as the representative of that committee on Committee D-18 was formally approved.

During the year Committee D-18 has completed the preparation of test procedures for conducting tension tests and shear tests and for the determination of modulus of elasticity of natural building stone. The procedures for conducting shear tests and for determining the modulus of elasticity have been approved by the committee for recommendation to the Society for publication as tentative subject to approval by letter ballot. No action by the Society is being asked at this annual meeting as it is expected to present the proposed tentative methods[1] to Committee E-10 on Standards at a meeting to be held subsequent to the annual meeting for acceptance as tentative standards.

The proposed tentative methods of test for shear and for determining the modulus of elasticity were submitted to letter ballot of the committee which consists of 18 members; 17 members have returned their ballots, all of whom have voted affirmatively.

The committee decided to consider further the methods for conducting tension tests and accordingly referred this outline of test procedure back to Subcommittee III on Testing Procedure for further study in line with certain suggestions that developed at the recent meeting of the committee.

The proposed definitions of terms relating to natural building stone published as information in the 1930 report[2] have now been approved by the committee for recommendation to the Society for publication as tentative with such editorial changes suggested as a result of a review of the definitions by Committee E-8 on Nomenclature and Definitions. No action by the Society is being asked at this annual meeting as it is expected to present the proposed tentative definitions[1] to Committee E-10 on Standards at a meeting to be held subsequent to the annual meeting.

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[1] These methods were accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931 and appear on pp. 834 to 847. See Editorial Note p. 587.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 894 (1930).

The proposed tentative definitions of terms were submitted to letter ballot of the committee which consists of 18 members; 17 members have returned their ballots, all of whom have voted affirmatively.

The committee has received several well-founded criticisms of the three tentative methods of testing natural building stone[2] under its jurisdiction and has prepared certain minor changes in these test procedures which are given below and which the committee will recommend to the Society through Committee E-10 on Standards subsequent to the annual meeting.

Tentative Method of Compression Testing of Natural Building Stone (D 326 – 30 T):[3]

Figure 1.—It is proposed to add the words "or rift" to the caption and notes in this figure.

Tentative Method of Flexure Testing of Natural Building Stone (Determination of Modulus of Rupture) (D 327 – 30 T):[4]

Section 2.—It is proposed to change the requirement for sensitivity of the testing machine from the present value of "0.5 lb." to read "5 lb."

Figure 2.—It is proposed to add the words "or rift" to the caption and notes in this figure.

Tentative Method of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (D 328 – 30 T):[4]

Section 4 (b).—It is proposed to change the phrase "thoroughly wiped off with a dry cloth" to read "thoroughly wiped off with a damp cloth" and to add the following note at the end of this section:

NOTE.—The operator should distinguish between a damp cloth and a wet one. In starting the operation, the towel should be sprinkled lightly. When the surface of the specimen is properly mopped off, it should appear dry.

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[1] These definitions were accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931 and appear on p. 845. See Editorial Note, p. 587.—ED

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, pp. 1161–1168 (1930); also 1930 Book of A.S.T.M. Tentative Standards, pp. 510–517.

[3] The revision in this method was considered as editorial and accepted by Committee E-10 on Standards, August 6, 1931.

[4] The revisions in these methods were accepted by Committee E-10 on Standards, August 6, 1931. See Editorial Note, p. 587.—ED.

These proposed changes were submitted to letter ballot of the committee which consists of 18 members; 17 members have returned their ballots, all of whom have voted affirmatively.

Supplementary requirements on the sampling of stone governing the selection, size and shape of samples of stone for purpose of tests and the manner in which it is recommended that these specimens be cut up for test specimens, covering the various types of test specimens required, have now been acted upon by the committee including the revisions made at the recent meeting of the committee. This procedure, which was referred to in the 1930 report of the committee as having been developed in preliminary form will shortly be submitted to letter ballot vote of the committee, thus enabling the sampling procedure also to be recommended to the Society for acceptance as tentative.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee III on Testing Procedure.—This subcommittee, in addition to the restudy of the procedure for conducting tension tests mentioned earlier in the report, has also been instructed to make a study of the various fatigue and thermal tests. These tests are being studied in order that this subcommittee may also make recommendations as to whether such tests should be provided for and, if so, to outline the manner in which such testing should be made, developing these requirements based upon the best existing practice in physical studies of this kind on related materials.

Subcommittee IV on Uniform Cubing of Stone.—The outline of uniform cubing of stone mentioned in last years report has been prepared in final form by Subcommittee IV and will shortly be sent out to the members of Committee D-18 for letter ballot.

Subcommittee V on Surface Finishes.—The outline of terms and descriptions of various finishes for stone mentioned in the 1930 report has been further developed and reported upon by Subcommittee V, but is not yet in sufficiently complete form for submission to the committee for consideration. This description will therefore be given additional attention by the subcommittee.

This report has been submitted to letter ballot of the committee which consists of 18 members; 17 members have returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

F. Y. JOANNES,
Chairman.

H. S. BRIGHTLY,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Test for Modulus of Elasticity of Natural Building Stone, Method for Shear Testing of Natural Building Stone and Definitions of Terms Relating to Natural Building Stone, referred to in the report, were subsequently accepted for publication as tentative on August 6 by Committee E-10 on Standards and appear on pages 834, 839 and 845, respectively.

Revisions of the Tentative Methods of Flexure Testing of Natural Building Stone (Determination of Modulus of Rupture) and Test for Absorption and Apparent Specific Gravity of Natural Building Stone were accepted on August 6 by Committee E-10 on Standards. The methods in their revised form appear on pages 829 and 832, respectively. The change in the Tentative Method of Compression Testing of Natural Building Stone was approved as editorial.

REPORT OF COMMITTEE E-1
ON
METHODS OF TESTING

Committee E-1 on Methods of Testing reports considerable progress in the work of several of its technical committees, particularly on the part of the Technical Committee on Mechanical Testing, which technical committee has several very active subcommittees at work. As will be seen from the activities of the several sections of this technical committee, as set forth in some detail below, a number of new tentative standards and revisions in tentative standards are in prospect. Recommendations concerning these will probably be submitted to Committee E-10 on Standards so that the tentative standards may be published during the year.

Attention is also called to the statement appearing elsewhere in this report concerning the activities of the Technical Committee on Presentation of Data. This committee is making excellent progress through the holding of round table discussions in conjunction with its committee meetings in acquainting those interested with the possibilities of the newer theories concerning statistical analysis and in the methods of presenting test data.

Index to Methods of Testing.—Committee E-1 has again issued in mimeographed form a complete Index to the methods of test of the Society. One of the functions of the committee is to correlate the various methods as developed by the several standing committees, eliminating duplications of procedures where possible, and unifying the various descriptions of a given method of test. The Index is of considerable assistance in this connection since it not only makes evident where more than one procedure for the same determination appears in the Society's standards, but also keeps the standing committees advised as to where the various procedures that have already been prepared may be found, which frequently may be of considerable assistance when a standing committee has in mind the development of a new method of test. It is planned to issue a revised Index during the next few months, which will again be furnished to the representatives of standing committees serving on Committee E-1 and to committee officers, and to other members of the Society on request.

ACTIVITIES OF TECHNICAL COMMITTEES

Reports concerning the work during the year of the several technical committees are given below:

Technical Committee on Mechanical Testing (H. F. Moore, chairman):

As is customary, the work of the Technical Committee on Mechanical Testing has been carried on mainly through its various sections. It should be mentioned that the several proposed standards recommended by the sections and published with this report are published as information for the purpose of eliciting criticism and discussion. They have no official standing whatever in the Society.

Section on Tension Testing (R. L. Templin, chairman).—The Section on Tension Testing expects shortly to present for approval a revision of the Tentative Methods of Tension Testing of Metallic Materials (E 8 - 27 T). Several meetings of the section have been held, and a further meeting will be held during the annual meeting at which these revisions will be considered.

Section on Compression Testing .—Owing to the pressure of other work, W. A. Slater has felt compelled to resign as chairman of this section. His place has been filled by M. F. Sayre, Associate Professor of Mechanical Engineering, Union College, Schenectady, N. Y.

Section on Bend Tests for Ductility (A. B. Kinzel, chairman).—This section has prepared proposed Methods of Quantitative Bend Testing using elongation of a metal on the outside fiber as a measure of ductility. These methods were published as information in the report of the committee last year.[1] The section has been giving further consideration to the proposed methods and is expected to submit a further report shortly.[2]

Section on Indentation Hardness (J. R. Townsend, chairman).—This section has been studying the Rockwell hardness tests during the past year. Methods of calibrating the apparatus and the technique of making tests and caring for machines have been discussed. The section is submitting as information proposed Methods of Rockwell Hardness Testing of Metallic Materials, as given in Appendix I to this report. This section is also working on proposed specifications for standardizing test blocks for Rockwell machines.

Section on Effect of Speed of Testing (J. H. Smith, chairman).—This section has prepared Proposed Requirements for Speed of Tension Testing of Metallic Materials, which are given in Appendix

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 907 (1930).

[2] See Editorial Note, p. 594.—ED.

II as information. It is obvious that the effect of speed of testing varies widely for different materials, and that in many cases the speed of the head of the testing machine gives a very poor measurement of the rate at which the specimen is strained. The requirements developed are for tests within the elastic range of a material in which the rate of application of load may be noted by an inspector and held within the proper limits. Beyond the elastic range of ductile materials, the speed of head will probably be satisfactory.

Section on Elastic Strength (F. B. Seely, chairman).—This section has laid before the Technical Committee on Mechanical Testing propositions for re-definition of elastic strength and suggested new methods for determining it. The section felt that it would be impossible to do away with the old terms "proportional limit," "elastic limit," and "yield point." However, they have recommended a new term which is a more general term than any of the above. This term is "yield strength" which may be characterized as a stress below which inelastic action for a material does not exceed a certain specified tolerence. The section believes that the use of this term could be introduced and become rather general and that it would do away with the confusion in discussion of elastic strength. The methods proposed for making this change are four in number, and the fact is recognized that no one method is suitable for all materials. The proposals of the section are given in Appendix III to this report.

Section on Impact Testing (J. M. Lessells, chairman).—This section has before it perhaps the most difficult problems of any section of this technical committee. The problems include correlating and standardizing test methods and studying the *meaning* of impact tests, so that this study of correlating and standardizing may be intelligently done. The impact test is in the curious position of having come into rather widespread use without there being any great idea of its precise significance. This committee will probably have to do considerable studying into the nature of the test, and possibly some research before standardization of methods becomes feasible.

A Further Résumé of the Notched-Bar Impact Test in the Light of Present Knowledge, which summarizes recent discussions of the impact test and recent discussions of its significance as correlated to experience in service, is presented as Appendix IV to the report.

Section on Thin Sheet Metals.—This section has recently been reorganized with Mr. C. H. Marshall of the Bell Telephone Laboratories as chairman, and the reorganized section is taking up the work of preparing further standards relating especially to the testing of thin sheet metals.

Technical Committee on Consistency, Plasticity, Etc. (E. C. Bingham, chairman):

This technical committee has before the Society certain definitions which were published as information in previous reports of Committee E-1. Some comments have been received in respect to these definitions, but the committee is not yet prepared to make final recommendations concerning the publication of the definitions as a tentative standard.

The committee is promoting research by individuals such as that conducted by Mr. R. A. Stephens and Mr. E. C. Bingham upon the direct measurement of the consistency of pitch-like substances based upon the flow of materials in a tube, the results being expressed in absolute units. The method used depends upon subjecting a plug of pitch in a glass tube to pressure in alternating directions and reading the amount of flow with a comparator. Since the material can be maintained at a constant temperature in a water bath, one of the principal difficulties in such a determination is obviated.

The chairman of the committee reports upon a further investigation carried out with Mr. F. C. Eaton upon the melting point of coal-tar pitch by the ring-and-ball method which showed that the melting point is subject to considerable variation due to the exposure of the sample by which volatile materials are expelled.

The committee has been in correspondence with the U. S. Bureau of Standards looking toward the investigation by the Bureau of the absolute viscosity of water for the purpose of developing a fundamental standard.

Technical Committee on Size and Shape (L. T. Work, chairman):

Two sections of this technical committee have been quite active during the year.

Section on Sub-Sieve Sizes (G. S. Haslam, chairman).—The work of this section was brought to the point where the committee is prepared to recommend for publication as tentative the proposed Method of Analysis for the Particle Size Distribution of Sub-Sieve Size Particulate Substances which was published as information with the 1930 report of Committee E-1.[1]

The section is desirous of fostering a centralized investigation of methods other than microscopic measurement and their relation to the microscopic method. With this in mind it has communicated with a number of interested industrial organizations to ascertain the advisability of proceeding with a scholarship program. While this plan appeals to the majority of the organizations approached it would appear that the present time is not altogether opportune for the launching of such a project. Further work on this program, however, will be carried out during the year.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 919 (1930).

Section on Coarse Screens (F. H. Jackson, chairman).—This section has had before it the question of standardizing either the round-hole screen or the square-mesh screen for use in making mechanical analyses of materials coarser than the No. 4 sieve. The mineral aggregates associations have recommended to the Federal Specifications Board a series of standard sizes of aggregates based on the use of square-mesh screens which recommendation has been accepted by the Board for incorporation in its specifications for aggregates. This suggested the desirability of the section considering square-mesh screens as a standard and the section has recommended to Committee E-1 that sieves with square openings be used in the classification by size of such materials as crushed stone, gravel, blast-furnace slag, etc., when used as coarse aggregate in concrete or in various types of road construction. In making this recommendation it is pointed out that from the standpoint of accuracy there is little to choose between the two types (see 1928 report of Committee E-1);[1] that there are certain factors favorable to the use of square-mesh sieves in that the same shape of aperture is used for both fine and coarse aggregates, thus facilitating the plotting of sieve analyses; that, on the other hand, the majority of current specifications use round-hole screens, but that the trend seems to be in the direction of using square-mesh sieves; and, finally, that it is practically feasible to convert results obtained with either shape of aperture into equivalent values based on the other.

In view of the fact that for the testing of certain materials, such as coal, round-hole screens are used, the section developed proposed Specifications for Round-Hole Screens for Testing Purposes which are appended to this report as information.[2] These specifications will come up for consideration in Committee E-1 looking toward their submission to the Society during the coming year through Committee E-10 on Standards for publication as tentative.

Technical Committee on Thickness Measurement (W. E. Emley, chairman):

In order to promote further discussion in respect to the proper method of measuring the thickness of material, a paper prepared by the chairman of the technical committee on Measurement of Thickness of Textiles and Similar Materials, appears as Appendix V to this report.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 623 (1928).

[2] These specifications were accepted for publication as tentative by Committee E-10 on Standards and appear on p. 1032. See Editorial Note, p. 594.—ED.

Technical Committee on Presentation of Data (W. A. Shewhart, chairman):

In the 1930 report of Committee E-1, the technical committee set forth the following six specific objects of interest to all engineers concerned with the testing and the specification of the qualities of raw materials:

1. Most efficient method of measuring a quantity when the measurements are subject to error.
2. How many measurements shall be taken?
3. How to correct observed data for errors of measurement.
4. How to determine when the variability in a set of data is greater than should be left to chance.
5. How shall a representative sample be selected?
6. How large a sample shall be taken?

The committee has made some progress in attaining these objects through the discussions that have been held at its meetings. Additional contributions will be made through discussions that take place at a meeting of the committee to be held during the annual meeting of the Society. These problems have been discussed at some length in a book, of which the chairman of the technical committee is author, entitled "The Economic Control of Quality of Manufactured Product."

The committee believes that one of the most important general subjects to be considered is the acquisition of good data. The members of the Society are essentially interested in discovering the physical properties of materials and the laws interrelating these properties. Since both the properties and laws are inherently statistical, recent developments in the theory of statistical inference are of interest.

Since the acquisition and use of good data depend upon an understanding of the scientific method, the committee has in mind holding a symposium on this subject at the annual meeting of the Society in 1932. Four topics to be included in such a symposium are suggested:

1. The need for good data in A.S.T.M. work.
2. Scientific method of getting good data based upon the older concept of causation.
3. Scientific method of getting good data based upon the modern concept of statistical causality.
4. The rôle of mind and its training.

A further symposium that would materially aid in the development of this subject and which might be held at the 1933 annual meeting would be one on the control of quality of raw materials which might include the following four topics:

1. Economic advantages of control of quality of raw materials.

2. Specification of qualities of materials.
3. Methods of detecting lack of control of quality of materials.
4. Inspection methods under controlled conditions.

The basic theory underlying such a series of papers is summarized in the book mentioned above.

A number of the standing committees of the Society have expressed a keen interest in the activities of the technical committee up to the present time and recognize the possibilities of a better analysis of data and of proper presentation and the effects that the work may have upon the standardization work of these committees both in respect to methods of testing and specifications.

This report has been submitted to letter ballot of the committee, which consists of 54 members; 33 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

EDITORIAL NOTE

Subsequent to the annual meeting the committee approved the proposed Tentative Specifications for Round-Hole Screens for Testing Purposes and the proposed Tentative Method of Bend Testing for Ductility of Metals for submission to the Society for publication as tentative through Committee E-10 on Standards. The specifications and method were accepted for publication as tentative on August 6 by Committee E-10 and appear on pages 1032 and 1034, respectively.

APPENDIX I

PROPOSED METHODS OF ROCKWELL HARDNESS TESTING OF METALLIC MATERIALS[1]

The Rockwell hardness tester is essentially a machine that measures hardness by determining the depth of penetration of a penetrator into the specimen under certain arbitrary fixed conditions of test. The penetrator may be either a steel ball or a diamond cone. The hardness is expressed as a number which is obtained by subtracting the penetration from an established constant. A minor load of 10 kg. is first applied which causes an initial penetration which sets the penetrator on the material holding it into position. The dial is set at zero on the black-figure scale, and the major load is applied. This major load is customarily 60 kg. or 100 kg. when a steel ball is used as a penetrator, but other loads may be used when found necessary, and 150 kg. when a diamond cone is employed. The ball penetrator is $\frac{1}{16}$ in. in diameter normally but other penetrators of larger diameter such as $\frac{1}{8}$ or $\frac{1}{4}$ in. may be employed for soft metals. A variety of loads and penetrators are thus provided and experience decides the best combination for use.

After the pointer comes to rest upon the application of the major load, the major load is then removed leaving the minor load still applied to the specimen. The difference in penetration between the major load and the minor load is then revealed by the dial.

Apparatus

1. *Rockwell Scales.*—Two scales of hardness shall appear on the dial of the machine since two loads and two penetrators are employed. When scales other than those specified in Paragraphs (*a*), (*b*) and (*c*) are employed, the diameter or type of penetrator, the major load, and the scale used (whether red or black divisions) shall be reported. Other loads and penetrators may be employed but the loads and the penetrators that have been found to be the most useful and which have been adopted as standard are specified in Paragraphs (*a*), (*b*) and (*c*).

(*a*) The "B" scale or red divisions shall be used when a 100-kg. major load and a $\frac{1}{16}$-in. ball penetrator are employed.

(*b*) The "C" scale or the black divisions shall be used when a 150-kg. major load and the diamond cone penetrator are employed.

(*c*) For testing soft metals, the "E" scale is recommended. The "E" scale employs a $\frac{1}{8}$-in. ball penetrator, a minor load of 10 kg. and a major load of 100 kg. The dial shall be turned so that the pointer reads at "set" (or B-30) before applying the minor load. After the major load has been applied and removed, the hardness shall be read on the red scale.

2. *Penetrators.*—The penetrator may be either a steel ball or a diamond cone. The steel ball penetrator shall ordinarily be $\frac{1}{16}$ in. in diameter but other penetrators of a larger diameter such as $\frac{1}{8}$ in. or $\frac{1}{4}$ in. may be employed for soft metals.

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[1] **These proposed methods have been prepared under the auspices of the Technical Committee on Mechanical Testing by the Section on Indentation Hardness Testing, Mr. J. R. Townsend, chairman, as a section of general methods of hardness testing.** They are published for **information and criticism, and communications should be addressed to** Mr. J. R. Townsend, **Bell Telephone Laboratories, 463 West St., New York City.**

3. *Anvil.*—The anvil used for flat surface test pieces shall be a bearing surface for the material of about $\frac{3}{16}$ in. in diameter. It shall be hard enough so that no visible indentation is made when the thinnest material is tested.

4. *Test Blocks.*—It is recommended that the following test blocks be available for checking the Rockwell hardness tester. For the "B" scale employing the 100-kg. load and the $\frac{1}{16}$-in. diameter ball, and reading on the red figures, blocks constructed of brass or similar material and having a hardness of approximately B-15, B-30, B-55, B-65, B-80, B-90, and B-100 are used. For the "C" scale employing the diamond cone and 150-kg. load and reading on the black figures, blocks having a hardness of approximately C-20, C-50, and C-70 are commonly employed. These blocks may also be calibrated for the 60-kg. load with a $\frac{1}{16}$-in. diameter ball, and the 150-kg. load with the $\frac{1}{16}$-in. diameter ball. For the "C" scale, hardened steel blocks may be employed and for any other scales blocks made of suitable material to give the desired hardness range may be employed.

TEST SPECIMENS

5. *Thickness of Specimen.*—There is necessarily a limit to the thickness of metal that may be satisfactorily tested. The practical limit of thickness for non-ferrous metals employing the $\frac{1}{16}$-in. diameter ball and the 100-kg. load is of the order of 0.020 in. Hardness readings taken on metal less than 0.020 in. in thickness give a lower reading than that obtained for metals of the same hardness but thicker. Material much thinner than 0.020 in. cannot be tested satisfactorily on the hardness tester. The same precautions apply to steel where the diamond cone is used. As a general rule the indentation should not show through the specimen and no material so thin as to cause indentation of the anvil shall be tested. Should damage to the anvil result in any instance the anvil shall be replaced. Anvils showing the least perceptible dent will give inaccurate results. All tests should be made on one thickness of metal. Irregularities of fit between more than one specimen will affect the result.

PROCEDURE

6. *Procedure.*—Before using the machine and each time the indenting tool is removed from its seat, the machine shall be operated several times on a piece of scrap material in order to firmly settle the penetrator, anvil, and moving parts of the machine. An average reading shall be made on at least one of the standard test blocks nearest to the hardness of material to be tested.

The test piece shall be placed on the anvil and the capstan screw elevated to bring the specimen against the penetrator. To apply the minor load of 10 kg. the capstan screw shall be continued to be elevated until the reference mark on the gage stem appears at the edge of the gage. At this point the pointer shall appear within ±5 divisions of the zero on the black division scale at the top of the dial. If the elevating screw has been turned too far, the minor load shall be removed and a new spot selected for the test. The last movement of this screw must always be in such a direction as to elevate the specimen. After the minor load has been applied, the dial pointer shall be set at zero on the black-figure scale.

In applying the major load, the operating handle shall be allowed to move without interference until the major load is completely applied. This may be observed in two ways, (1) when the pointer suddenly slows down, or (2) watching the weight arm to see that it is completely free from the control of the dash pot. When the major load has been completely applied, the operating handle shall be immediately brought back to the latched position. This shall be accomplished in less than two seconds after the major load is completely applied. There must be no shock given to the machine in any way.

The Rockwell ball should occasionally be replaced by a new one and the operator should be on the lookout for any permanent deformation of the ball which will ordinarily be indicated by high readings on the standard test blocks.

All hardness data obtained with this method shall be prefixed by a letter showing whether the hardness value was determined on the "B" scale, the "C" scale or the "E" scale.

ADJUSTMENT AND CALIBRATION OF ROCKWELL HARDNESS APPARATUS

7. *Adjustments: (a) Dash Pot.*—The dash pot on the Rockwell tester shall be so adjusted that the operating handle completes its travel in from 5 to 10 seconds with no specimen on the machine and with the machine set up to apply a major load of 100 kg.

(*b*) *Index Lever Adjustment.*—The following tests (and adjustments, if necessary) shall be made as follows: Place a piece of material on the anvil and turn the capstan elevating nut to bring the material against the ball penetrator. Keep turning to elevate the material until the hand feels positive resistance to further turning, which will be felt after the 10-kg. minor load has been picked up and when the major load is encountered. When excessive power would have to be used to raise the work higher, take note of the position of the pointer on the dial, after setting the dial so that C-0 and B-30 are at the top. Then if the pointer stands between B-50 and B-70 no adjustment is necessary; if the pointer stands between B-45 and B-50, adjustment is advisable, and if the pointer stands anywhere else, adjustment is imperative. As the pointer revolves several times when the work is being elevated the readings mentioned above apply to that revolution of the pointer which occurs as the reference mark as the gage stem disappears into the sleeve. The object of the adjustment is to see that the elevation of the specimen to pick up the minor load shall not be carried so far as to cause even a partial application of the major load, which to make a proper test, shall be applied only through the release mechanism.

The adjustment of the index lever, if necessary, shall be made as follows: When the test piece is elevated until it starts to pick up the major load, loosen the lock nut of the screw through the index lever which carries at its lower end a small steel plate engaging the ball on the penetrator shaft, while using a small screw-driver to firmly hold the screw until after the nut is loose. Then turn the screw very slightly and note the result on position of the gage pointer which should be between B-60 to B-70 before reclamping the screw with its lock nut.

8. *Calibration With Test Blocks.*—In order to check the machine to determine if it is in good working order and giving standard readings test blocks shall be employed. In order for the results of two or more machines to check accurately, it is necessary that each machine be calibrated with these test blocks. Variations in readings due to adjustment, wear, or friction in the operating parts are liable to exist. A satisfactory method of making such tests is to first calibrate the test blocks by taking the minimum and maximum readings of three or more Rockwell machines that are known to be in good adjustment and use these readings as the correct calibration of the block. All other machines may then be adjusted until they agree with the readings of the test blocks. Since there is some variation in the material of which the test block is made, it is desirable to make at least five readings, one in the center and four readings, one in each

corner of the block. In the case of the inspection of material between a producer and a consumer, the producer and consumer should agree upon the standard test block that is used to calibrate the machine.

In any instance the calibrated reading of the machine shall be employed and the corrections from the standard blocks applied. It is good practice to keep the Rockwell machines agreeing to within 2 hardness numbers in the hard ranges and 4 hardness numbers in the soft ranges. Tests shall be made on standard test blocks before and after a given group of readings. The average reading of the machine on the test blocks before and after the group of tests shall be considered the average reading of the machine and the correction applied to this value.

PRECAUTIONS

9. (*a*) *Protection Against Vibration.*—If the bench or table on which the Rockwell tester is mounted is subject to vibration, such as felt in the vicinity of other machines, the tester should be mounted on a metal plate on sponge rubber at least 1 in. thick or any other type of mounting that will effectually eliminate vibration from the machine. Otherwise the pointer will penetrate farther into the material than when such vibrations are absent.

(*b*) *Cushioning of Latch.*—If, when the operating handle is being returned to its normal position, the latch operates with such a snap as to noticeably change the position of the dial pointer, felt or rubber washers should be placed under the trip mechanism in order to cushion this blow. If this snap is severe, difference in reading of several hardness numbers may result.

(*c*) The specimens employed for hardness determinations shall be prepared with some care. The surface oxidation shall be removed and this may be accomplished by rubbing lightly with a suitable abrasive and should sheet metal be employed special care should be taken with material that is curved. The concave side of the curved metal should face toward the penetrator. If such specimens are reversed an error will be introduced due to the flattening of the metal on the anvil.

(*d*) Specimens which have sufficient overhang so that they do not balance themselves on the anvil shall be properly supported.

(*e*) In testing cylindrical specimens, a V-notch anvil shall be used and the penetrator applied over the axis of the rod. The specimen shall lie flat in the V-notch anvil and directly in line with the penetrator.

(*f*) The penetrator and anvil should not be brought together without a test piece between them, otherwise the anvil will be indented and the ball flattened.

(*g*) The minor load shall be applied so that the pointer approaches within ±5 divisions from top of the dial when the notch on the lower dial stem just comes in line with the edge of its sleeve.

(*h*) The dial gage plunger shall move free without appreciable change of friction in any position.

(*i*) The time of application of the major load shall be established and accurately adhered to when comparing results. As a general rule an interval of full application of the major load of not more than one second is best. For soft metals the penetration will "creep," causing variations as high as 10 hardness numbers. With such metals the operating lever should be brought back the moment it is seen that the major load is fully applied.

APPENDIX II

PROPOSED REQUIREMENTS FOR SPEED OF TENSION TESTING OF METALLIC MATERIALS

(For information and criticism only)[1]

In the testing of materials up to and beyond their elastic limits, or their yield strength, the phenomena of plastic flow in many materials is affected by the rate of deformation. For such materials the rate of application of load is evidently a factor of some importance when their mechanical properties are to be determined. Preliminary research has indicated that this effect of speed of deformation has a more pronounced effect in some materials than in others; moreover, the problem is complicated by the effect of varying cross-sections and gage lengths given in the specifications for various metallic materials.

While, in general testing of materials, the rate of *deformation* in the vicinity of the elastic limit, or the yield point, may be considered the fundamental speed factor to be considered in determining elastic limit, or yield point, yet for convenience in making a test it seems desirable to observe and control the rate of application of load to the specimen. This is justified in view of the fact that the rate of *strain* (deformation) multiplied by the modulus of elasticity of the material gives the rate of change of *stress*, measured in pounds per square inch.

Experiments have shown that below the yield range nearly all the motion of the cross-head of a testing machine is taken up by slip of grips and deformation of parts of the testing machine. These irregularities are so large as to render speed of head quite unreliable as a measure of rate of strain below the yield range. Therefore, it is proposed that the speed of testing within this range be gaged by the rate of application of stress.

RATE OF APPLICATION OF STRESS

1. *Rate for Determining Yield Point.*—In tension tests the rate of application of stress, R, up to the yield point shall be within the following limits:

Structural steel........................ 24 000 ± 5000 lb. per sq. in.

NOTE.—This list is to be extended later as test data become available for other materials.

2. *Factors Affecting Rate.*—The rate at which stress is being applied will depend on a number of factors, speed of head of testing machine, method of attaching specimens, length and cross-section of specimens, etc. Therefore, one or more extra specimens should be provided with each lot to be tested to serve as pilot specimens in trial tests for determining the speed of head of testing machine to be used to give rate of loading within the limits specified above.

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[1] These proposed requirements have been prepared under the auspices of the Technical Committee on Mechanical Testing by the Section on Effect of Speed of Testing, J. Hammond Smith, chairman. They are published for information and criticism, and communications should be addressed to Mr. J. H. Smith, Department of Civil Engineering, University of Pittsburgh, Pittsburgh, Pa.

It is intended that these requirements when adopted will be added to the Tentative Methods of Tension Testing of Metallic Materials (E 8 – 27 T), see *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872

3. The testing machine may be operated at any convenient rate up to the load (well below the elastic limit or the yield point) under which the specimen is firmly seated in the holders, as shown by the load shown on the load indicating apparatus of the testing machine.

4. *Rate for Determining Tensile Strength.*—For determining the tensile strength of metallic materials the speed of the pulling head of the testing machine shall be considered as a satisfactory index of rate of deformation, and this speed shall be within the following limits:

NOTE.—A table of definite values has not as yet been prepared for speed of head to be used in determining tensile strength, meanwhile the values given in Section 17 of the Tentative Methods of Tension Testing of Metallic Materials (A.S.T.M. Designation: E 8 - 27 T) of the American Society for Testing Materials,[1] should be regarded as maximum allowable values. They are probably too high for non-ferrous metals.

DETERMINATION OF RATE OF INCREASE OF STRESS DURING A TEST

5. (*a*) *Procedure.*—A specimen shall be placed in the grips of the testing machine and the load applied at a speed of head (or setting of valve in the case of a hydraulic machine) which is estimated to give the desired rate of increase of stress. After the specimen has been firmly seated in the grips, as shown by the regular increase of load, the time and the load, L_1, shall be noted. The loading shall be continued without stopping the machine and the time at which some higher load, L_2, below the yield point is reached shall be noted. The load L_1 may be taken at approximately 15 per cent and L_2 at approximately 75 per cent of the estimated yield point of the material.

(*b*) Determinations for specimens held in wedge grips or any kind of sliding grips should be made at the first application of the load on the specimen, as subsequent loadings will be at a much higher rate for a given speed of head of the testing machine.

6. *Calculation.*—The rate of increase of stress, R, may be calculated from the following formula:

$$R = \frac{L}{At}$$

where R = the increase of stress in pounds per square inch per minute;
A = the section area of specimen in square inches;
L = the load interval in pounds = $L_2 - L_1$;
t = the time of load interval in minutes.

NOTE.—*Example:* A material is estimated to have an elastic limit of 36,000 lb. per sq. in.

A = 0.20 sq. in.

Therefore the values of loading limits should be, (approximately) as follows:

L_1 = 1080 (15 per cent of 0.20 sq. in. at 36,000)
L_2 = 5400 (75 per cent of 0.20 sq. in. at 36,000)
$L = L_2 - L_1 = 5400 - 1080 = 4320$
t = 1.1 minutes (from experiment)

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part I, p. 1067 (1927); also 1931 Book of A.S.T.M. Tentative Standards, p. 872.

From these values R is calculated as follows:

$$R = \frac{L}{At} = \frac{4320}{0.2 \times 1.1} = 19{,}650 \text{ lb. per sq. in. per minute}$$

If the material of this example is structural steel, the specification is satisfied. See Section 1 in which the limiting values or R for structural steel are 19,000 and 29,000 lb. per sq. in. per minute.

After a few trials for a given material the machine may be calibrated in terms of speed of head, or of valve setting, so that further tests for determination of R will be unnecessary.

APPENDIX III

PROPOSED DEFINITIONS OF TERMS RELATING TO METHODS OF TESTING[1]

Elastic Limit.—The greatest stress which a material is capable of developing without a permanent deformation remaining upon complete release of the stress.

NOTE.—It is a matter of experience with many materials, especially with many metallic materials, that using ordinary methods of testing, the values found for elastic limit by means of observations of permanent deformation (set) after release of stress do not differ widely from the values found for proportional limit, the latter being defined as:

Proportional Limit.—The greatest stress which a material is capable of developing without a deviation from the law of proportionality of stress to strain (Hooke's Law).

Since the determination of proportional limit is much more readily made than is the determination of elastic limit, it is customary to accept the proportional limit as equivalent to the elastic limit for such materials, and hence the proportional limit is frequently called the "proportional elastic limit."

In certain specifications[2] of the Society, the term "Elastic Limit" is used to designate a value obtained by a test method which does not involve the release of stress during a test, but which does involve the determination of a limiting load at which there occurs an appreciable increase in rate of strain with respect to stress. This method may determine, for some materials, a satisfactory value of the proportional elastic limit, but the property termed "Yield Strength" determined by the "set method" as described below, is felt to be a more widely satisfactory and significant measure of the desired strength property of the material.

Yield Strength.—The stress at which a material exhibits a specified limiting permanent set.

NOTE.—It is usually impracticable and probably impossible to determine the stress at which inelastic action in a member *begins.* Plastic yielding in nearly all members (including the specimen in a carefully controlled laboratory test) starts as local actions and becomes measurable only after many local internal adjustments and accommodations have occurred, and after a considerable portion of the member is affected by the yielding.

The limit of usefulness of many materials, especially metals, in members subjected to approximately static loading at ordinary temperatures is therefore determined by a measurable value of plastic yielding of the material above which the material is considered to be damaged and below which the damaging effects are considered to be negligible.

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[1] These proposed definitions have been prepared under the auspices fo the Technical Committee on Mechanical Testing by the Section on Elastic Strength of Materials, F. B. Seely, chairman. They are published for information and criticism, and communications should be addressed to Mr. F. B. Seely, University of Illinois, Urbana, Ill.

These proposed definitions are a proposed revision of the Tentative Definitions of Terms Relating to Methods of Testing (E 6 - 30 T), see *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1263 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 898.

[2] See 1930 Book of A.S.T.M. Standards, Part I, p. 180.

The following methods are recommended for determining the yield strength of a material:

1. For material that has a "sharp-kneed" stress-strain diagram and hence exhibits at a certain stress the special characteristic of yielding without increase in stress. Two satisfactory methods are in use:

(*a*) *The "Drop of the Beam" Method.*—In this method the load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at approximately a steady rate. When the yield strength of the material is reached the increase of load stops, but the operator runs the poise a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device, there is a sudden halt of the load-indicating pointer corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken as the yield strength. This method of determining the yield strength requires only one man to conduct a test.

(*b*) *Total Strain Method Using Dividers.*—This method is frequently called the "dividers method." In this method an observer with a pair of dividers or other suitable apparatus, watches for visible elongation between two section marks on the specimen. When visible stretch is observed, the load at that instant is noted, and the stress corresponding to the load is taken as the yield strength.

Note on Yield Point.—The above two methods determine what is usually called the yield point which is commonly defined as follows:

Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

It should be noted that only materials that exhibit this unique phenomenon of yielding have a yield point. The term yield point should not be used in connection with material whose stress-strain curve in the region of yield is a smooth curve of gradual curvature.

2. For material whose stress-strain diagram in the region of yield is a smooth curve of gradual curvature.

(*a*) *The Set Method.*—This method can be used, if desired, for materials having "sharp-kneed" stress-strain diagrams, but is especially adapted to materials whose stress-strain diagram in the yield range is a smooth curve of gradual curvature.

For nearly all materials, if at any point on the stress-strain diagram such as r in Fig. 1, the load is released the diagram for decreasing load will follow a line, rm, approximately parallel to the initial portion, OA, of the diagram for increasing load. Om will then give the approximate value of the permanent set after the release of the stress OR. The value of this set is given in percentage of original gage length. Thus to determine the yield strength by the "set method," it is necessary to secure data (autographic or numerical) from which a stress-strain diagram may be drawn. Then with the stress-strain diagram (Fig. 1) lay off Om equal to the specified value of the set, and draw mn parallel to OA and thus locate r, the intersection of mn with the stress-strain diagram. Draw Rr parallel to the X axis and then OR gives the value of the yield strength.

In reporting values of yield strength obtained by this method, the specified value of "set" used should be stated in parentheses after the term yield strength. Thus:

Yield strength (set = 0.1 per cent) = 52,000 lb. per sq. in. indicates that at a stress of 52,000 lb. per sq. in. the approximate permanent set of the material reached the value of 0.1 per cent of the original gage length.[1]

In using this method, an extensometer reading to 0.0001 in. per inch of gage length would be sufficiently sensitive for most materials. It will be observed that the elastic limit and proportional limit are special values of the yield strength in which the specified limiting set is not measurable with the instruments used and hence is considered to be zero.

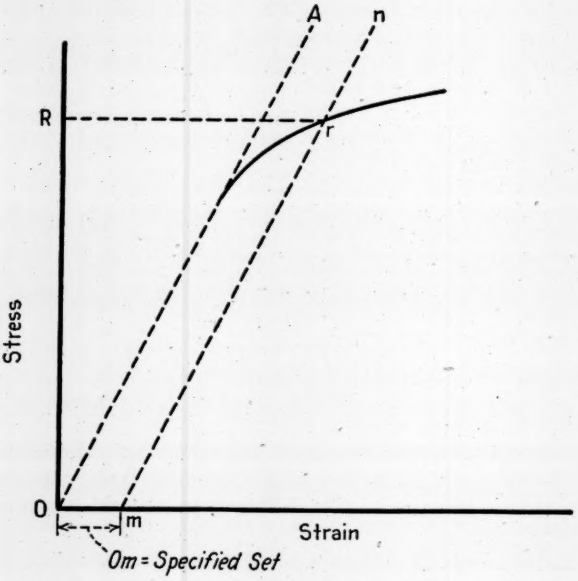

FIG. 1.—Stress-Strain Diagram.

(*b*) *Approximate Method Without Stress-Strain Diagram.*—For tests to determine the acceptance or rejection of material whose stress-strain characteristics are well known from previous tests of similar material in which stress-strain diagrams were plotted, the total strain corresponding to the stress at which the specified permanent set occurs will be known within satisfactory limits; therefore, in such tests a specified total strain may be used, and the stress on the specimen, when this total strain is reached, is the value of the yield strength. The total strain can be obtained satisfactorily by use of an extensometer or in some cases by use of dividers particularly if the surface of the specimen is prepared so that the line made by the dividers is a fine line and if it is observed through a reading glass. But it is recommended that this approximate method be used only after agreement between producer and consumer, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the set method to settle any misunderstandings.

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[1] A value of 0.20 per cent of the gage length has been used rather widely for metals.

APPENDIX IV

A FURTHER RÉSUMÉ OF THE NOTCHED-BAR IMPACT TEST IN THE LIGHT OF PRESENT KNOWLEDGE

From discussions which the members of the Section on Impact Testing of Committee E-1 have had, it was thought desirable to include some information on the notched-bar impact test as regards (*a*) ability to detect flaws and (*b*) latest information from papers published by the New International Association for Testing Materials.

Ability to Detect Flaws:

It is now generally recognized that the notched-bar impact test, although giving arbitrary values which in the light of present knowledge cannot be used directly in design, still is valuable as a control test for materials. In most of the structural nickel-chromium steels, it has been known for many years that when such steels are slowly cooled from 600° C., the notched-bar impact value is very low as compared with the same steel rapidly cooled from the tempering temperature. The tensile strength values, however, remain the same for both conditions.[1] An explanation[2] has now been advanced to account for this phenomenon of temperature brittleness. It has been suggested that alpha-iron may at higher tempering temperatures dissolve an appreciable amount of carbide which on quenching is retained in solid solution but which on slow cooling is redeposited at the grain boundaries, giving rise to a brittle network throughout the mass.

As far as it affects control of heat treatment, the notched-bar impact test appears to have a real place in the field of testing.

The value of the test in its ability to detect flaws seems also well established. Mr. W. Rosenhain[3] in discussing the paper by Charpy and Cornu-Thenard stated:

> The test emphasized, however, the conclusion that when a really important variation was obtained in the impact figure, that is, a variation of 20 to 40 per cent or even 60 per cent, then a result was obtained which meant something extraordinarily definite and important. He (Dr. Rosenhain) was not exceeding a conservative statement of the facts when he said that in any experience extend-

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[1] F. C. Langenberg and N. Richardson, "Significance of Impact Test," *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part II, p. 131 (1922).

[2] J. H. Andrew and H. A. Dickie, "A Physical Investigation into the Causes of Temperature Brittleness," *Journal*, Iron and Steel Inst., Vol. 2, p. 359 (1926).

[3] Discussion by W. Rosenhain on paper by Charpy and Cornu-Thenard, *Journal*, Iron and Steel Inst., Vol. 11, p. 105 (1917).

ing over a large number of cases of failure in steel, he had yet to find an example where a piece of steel which had really behaved badly in practice had given a good impact figure. The value of the impact test could not always be judged on an absolute standard but if it was found that ordinary heat treatment could and did improve steel to a very large extent under the impact test although it might not improve it to any large extent under the ordinary tensile test, he thought that was very conclusive evidence that there was something wrong with that steel in the condition in which it was used.

Another case where failure in service of a nickel-chrome steel forging was found to reveal low notched-bar impact values was quoted by F. C. Langenberg and N. Richardson.[1] In this case the notched-bar values were doubled by heat treatment but the tensile values remained practically unchanged. In this paper, these authors state:

> No component of a gun, such as the jacket or tube, which has ruptured in service from a cause which cannot definitely be assigned to defective ammunition, excessive powder pressures, etc., has shown an impact value exceeding 6 ft-lb. on specimens tested in a small Charpy impact machine. It has therefore become the practice of Watertown Arsenal to take impact tests from all components of a gun and, regardless of their ordinary tensile properties and the acceptability of the forging as judged from this test, no piece is accepted unless the results on the small Charpy impact machine show a value of at least 6 ft-lb.

Recent publications on impact seem to confirm this view. For example, R. H. Greaves[2] comments as follows:

> It was stated as the experience of the Research Department at Woolwich, in 1920 that the number of cases investigated in which material has failed in service by cracking or fracture of some kind, and in which it has been found to give poor results in notch-bar tests, is much too large for the association to be accidental. Further experience of the last ten years has confirmed this view.

So that again we have certain evidence that this test is able to detect faulty material. In other words, low impact values per second may not mean liability to give failure in service but impact values very much lower than what can be obtained by proper heat treatment appear to be dangerous.

(*b*) *Latest Information*[3] *from Publications of New International Association for Testing Materials.*—Considerable work has been done in Europe recently on impact, and some mention will now be made of this work, particularly as to that to be presented at the Zurich meeting of the International Association for Testing Materials to be held September 6 to 12, 1931. Mailänder has found a transition zone from high to low impact values by varying the width of the test specimen (see Fig. 1). The high values are characterized by considerable deformation and a fracture of granular appearance. In the former case, considerable plastic flow due to slip under shearing stress takes place and in the latter case, cohesion failure occurs under the action of "triple-tension" stress.[1]

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[1] *Loc. cit.*, p. 135.

[2] R. H. Greaves, "Meaning of the Notched-Bar Impact Test for Investigation and for Acceptance Test Purposes," *First Communications*, New Internat. Assn. Testing Mats., Group A, p. 225 (1930).

[3] Prepared by R. E. Peterson, Research Laboratories, Westinghouse Electric and Mfg. Co.

Moser investigated the effect of variation of dimensions of the test piece on impact values. One of his conclusions was that the maximum volume of deformation was constant for a given test specimen for all metals, and also proportional to the width of the test specimen if this dimension only were changed. Sauerwald and Wieland working with non-ferrous metals have disputed Moser's generalization.

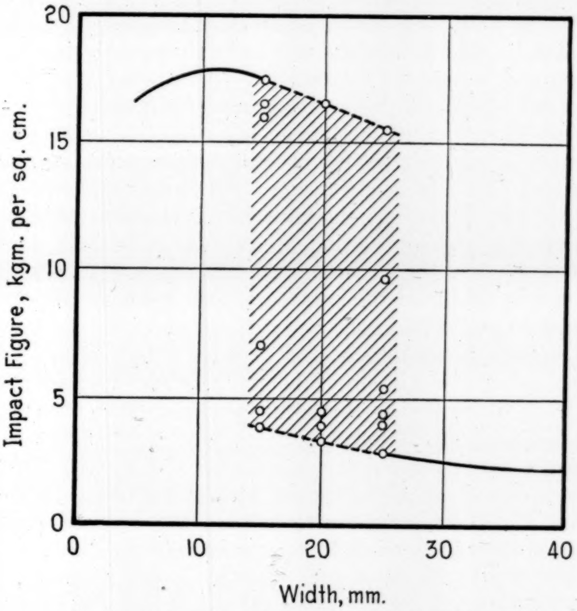

FIG. 1.—Relation of Impact Value and Width of Test Specimen.

It is obvious that further research is needed along the lines indicated above. Such work would undoubtedly have an important bearing on future standardization.

Respectfully submitted on behalf of the Section on Impact Testing,

J. M. LESSELLS,
Chairman.

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[1] "Triple-tension" stress exists when the three principal stresses on a particle (along axes X, Y and Z) are all *tensile* stresses.

APPENDIX V

MEASUREMENT OF THICKNESS OF TEXTILES AND SIMILAR MATERIALS

By W. E. Emley[1]

Thickness is defined in the dictionary as the least of the three dimensions of an object. For ordinary purposes, this definition is ample. We speak of the thickness of a plank as two inches or the thickness of a wedge as varying from three inches to zero, and are sure that we shall be correctly understood. On stopping to analyze such statements, we find that they are based on the time-honored practice of measuring thickness by laying a scale against the object, and that they include the idea of a reasonable tolerance.

Because of limitations of the human eye, the scale method of measuring thickness cannot be used without some magnifying device where a precision greater than about 0.01 in. is necessary. An optical magnifying device will enable us to see the division on the scale with sufficient precision, but at the same time it emphasizes the fact that the surfaces of the object are not plane. When the unevenness of the surfaces is beyond the permissible tolerance then the object has many different thicknesses, and we are compelled to select more or less arbitrarily two points in the two surfaces and take the thickness of the object as the distance between these points. Unless the locations of these points can be exactly described, it is probable that another operator will select two different points, and thus fail to check our measurements.

Optical methods can be relied upon to measure distances correctly but usually some auxiliary mechanical contrivance is required to define the end points. This is one of the factors which has limited the general adoption of optical instruments for thickness measurements. Other factors are the care and skill required for their manipulation, their relatively high cost, and their lack of ruggedness.

Where a precision greater than 0.01 in. is required, the principle involved in the machinists' micrometer has been found useful. The object is gripped between two plane, parallel jaws, and the distance between the jaws is indicated through a mechanical magnifying device. Instead of compelling the operator to select two points in the surfaces of the object, this method selects, more or less automatically, the positions of two parallel planes making contact with the object and defines thickness as the distance between these planes.

The force exerted through the jaws when gripping the object is counteracted by the elastic properties of the object, and these are functions of the elastic properties of the material and the size and shape of the object. The elastic properties of the object are beyond the control of the operator, but it is possible to control the force exerted on the jaws and to this extent control the positions of the defined planes between which the thickness is measured.

Measuring the thickness of a piece of metal by means of a machinists' micrometer is a special case where the object is so nearly incompressible that any small differences in the force used by the operator will not affect the results beyond the degree of precision required. The magnitude of the force used in operating the instrument is both variable and unknown. The positions of the defined planes are therefore also variable and unknown unless the object is practically incompressible. If the object is more highly compressible, then the precision will be of correspondingly lower degree. That a low degree of precision is sometimes satisfactory may be inferred from the fact that this method is recommended for measuring the thickness of such highly compressible materials as asbestos tape[1] and rubber gloves.[2] It is to be hoped that this low degree of precision was taken into account when setting the tolerances in these specifications.

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[1] Chief, Division of Fibrous and Organic Materials, U. S. Bureau of Standards, Washington, D. C.

A newer type of machinists' micrometer is provided with a ratchet which limits the amount of force which the operator can apply.

The instrument commonly used for measuring the thickness of highly compressible materials is called a thickness gage. It may be considered as an adaptation of the machinists' micrometer, in which one jaw is represented by a horizontal anvil and the other by a presser foot which is free to move in a vertical direction. The object is laid on the anvil and the presser foot lowered until it rests on the object. The distance between the anvil and presser foot is magnified mechanically. It will be seen that this instrument fits the description given above; that its use defines two parallel planes in contact with the object, and that the positions of these planes depend upon the elastic properties of the object and the force exerted through the presser foot.

In some of the older types, the presser foot was curved instead of plane. Theoretically, thickness might just as well be defined as the distance between the lowest point of the curved presser foot and the plane anvil as the distance between two planes. It was also argued that the use of a curved foot made it unnecessary to exert that care in maintenance which is required to make sure that the surface of a plane foot is always parallel to the surface of the anvil. However, this type has fallen into disuse, probably because it gave too great emphasis to small differences in the elastic properties of the objects.

In another type, the presser foot is operated by means of a spring. The thicker the object, the more the spring is compressed and the greater the force it exerts on the presser foot. Instead of having this force either automatically fixed or subject to the control of the operator, this design causes the force to vary with any change in the very dimension which is being measured and is, therefore, like the machinists' micrometer in that precise measurements can be made only when the object is practically incompressible. It is required for measuring the thickness of untreated insulating paper[3] and varnished cloth and varnished cloth tape,[4] although work is now under way in Committee D-9 on Electrical Insulating Materials towards standardizing the use of the ½-in. machinists' type micrometer for these materials. It is also recommended for testing felted and woven fabrics saturated with bituminous substances for use in waterproofing and roofing.[1]

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[1] See Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315 – 31 T), p. 996.

[2] See Standard Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground (D 120 – 23), 1930 Book of A.S.T.M. Standards, Part II, p. 1023.

[3] See Tentative Specifications for Testing Untreated Paper Used in Electrical Insulation (D 202 – 30 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1197 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 661.

[4] See Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 29 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 786 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 706.

In the type in most general use, the presser foot is operated by gravity. The force is fixed by the weight of the foot and the movable parts connected with it, and the force of the small spring used to take up the backlash of the gears. The area of the foot is circular and smaller than the anvil, so that the pressure exerted on the object per unit area is equal to the weight of the foot (and movable parts) divided by its area.

In the specifications for cord tire fabrics[2] and for tire fabrics other than cord,[3] it is required that the presser foot shall be dropped ¼ in. on to the object. This adds a dynamic force to the static force exerted by gravity on the presser foot. The magnitude of the dynamic force is dependent upon the height through which the foot falls. The ¼ in. is to be measured from the upper surface of the object, and the position of this surface must therefore be known. But the object is lying on the anvil, which fixes the position of its lower surface. If the position of the upper surface is also known, it would seem that the thickness of the object must be known, and any further measurement would be superfluous.

The weight of the presser foot and its area are controllable; the weight can be increased by putting a load on the plunger which carries the foot, and numerous feet of different sizes can be made interchangeable for the same plunger. Many combinations of these two factors are now in use, and attempts to standardize them for particular industries are now under way. Thus the rubber industry has pretty well standardized on a foot ¼ in. in diameter weighing 9 oz.; the textile industry is attempting to adopt a foot ⅜ in. in diameter weighing 6 oz. Many varieties are still carried on the books, however, as, for example:

A ¼-in. 9-oz. foot is specified for rubber products in general,[4] while for rubber gloves, the foot is ⅛ in. in diameter, and the pressure must be such that the glove will "slip without stretching."[5]

For woven textiles a ⅜-in., 6-oz. foot is required,[6] but for varnished cloth tape the foot is ½ in. in diameter, actuated by a spring;[7] for friction tape a ¼-in. 9-oz. foot is required;[8] for silk and cotton tape, the foot must be $\frac{7}{16}$ in. to ½ in. in diameter, but no load is specified;[9] for tire cord, a ⅜-in., 4-oz. foot is dropped ¼ in. onto the surface of the specimen;[10] for tire fabric a ⅜-in., 6-oz. foot is dropped ¼ in. onto the surface of the specimen.

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[1] See Standard Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 – 27), 1930 Book of A.S.T.M. Standards, Part II, p. 970.

[2] See Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 – 30), 1930 Book of A.S.T.M. Standards, Part II, p. 1085.

[3] See Standard Specifications for Tolerances and Test Methods for Tire Fabrics other than Cord Fabrics (D 122 – 30), 1930 Book of A.S.T.M. Standards, Part II, p. 1081.

[4] See Standard Methods of Testing Rubber Products (D 15 – 24), 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

[5] See Standard Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground (D 120 – 23), 1930 Book of A.S.T.M. Standards, Part II, p. 1023.

[6] See Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27), 1930 Book of A.S.T.M. Standards, Part II, p. 1102.

[7] See Tentative Methods of Testing Varnished Cloths and Varnished Cloth Tapes Used in Electrical Insulation (D 295 – 29 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 786 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 706.

[8] See Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 – 28), 1930 Book of A.S.T.M. Standards, Part II, p. 1036.

[9] See Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 – 27), 1930 Book of A.S.T.M. Standards, Part II, p. 1093.

[10] See Standard Specifications for Tolerances and Test Methods for Tire Cord, Woven and on Cones (D 179 – 30), 1930 Book of A.S.T.M. Standards, Part II, p. 1085.

For electrical insulating materials a ¼-in. foot on a ratchet micrometer is required;[1] the methods specified for rubber gloves, friction tape, and silk and cotton tape are cited above; for asbestos tape, the foot shall be $\frac{7}{16}$ to ½ in. in diameter and the pressure such that the specimen will "slip without stretching,"[2] for rubber tape the ¼-in., 9-oz. foot is specified.

The situation thus disclosed is indefensibly confusing and must obviously be a prolific source of errors. The measurement of thickness is usually considered to be so simple that it is entrusted to the least experienced operators. But if various kinds of materials are to be measured, as in a commercial testing laboratory, or in the purchase department of a corporation, extreme care is required to match each material with its proper measuring device. While the situation is in the present chaotic condition, it would seem opportune to try to adopt one single design of gage to be used by all industries.

The presser foot should be large enough so that it will not sink into the object unduly, and small enough so that any slight lack of parallelism with the anvil will not be too significant. It is noted that several of the specifications call for "a pressure of 8 oz." This statement is ambiguous, in that the reader cannot tell whether he should use a load of 8 oz. or a pressure of 8 oz. per sq. in. The former condition can be met and the latter ambiguity avoided by making the area of the presser foot 1 sq. in.

The indentation of the foot into the specimen is not a straight-line function of the pressure. At light pressures, small increments of pressure cause larger increments of deformation than is the case at heavier pressures. The pressure used should therefore be great enough so that a variation within a reasonable tolerance will make no significant difference in the indentation. Based on the properties of the materials as studied in the laboratory and on the designs of gages now in use, it seems that a pressure of 2 lb. per sq. in. will meet this requirement. If the presser foot is 1 sq. in. in area, then the weight of the foot and supporting plunger should be 2 lb. It is believed that with this weight, the friction between the plunger and its guides will be negligible.

A standard gage for use in measuring the thickness of any material might therefore be specified as follows: The anvil shall be plane and not less than 1½ in. in diameter. The presser foot shall be plane to 0.00005 in., parallel to the anvil within 0.0002 in., have a diameter of 1.1284 in. ±0.0005 in., and the total weight of the foot and the movable parts connected therewith shall be 2 lb. ±0.001 lb. These tolerances are based empirically on good machine shop practice.

The usual type of machinists' micrometer, and the other types of gages now in use, may be satisfactory in special cases. The operator should consider the limitations of the instrument and the elastic properties of the specimen and decide whether or not the measurements are likely to fall within the permissible tolerances.

Thickness can therefore be defined to mean the distance between the plane, parallel jaws of the testing instrument when they are in contact with the object and under a pressure of 2 lb. per sq. in.

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[1] See Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 31 T), p. 867.

[2] See Tentative Specifications and Test Methods for Asbestos Tape for Electrical Purposes (D 315–31 T), p. 996.

REPORT OF COMMITTEE E-4
ON
METALLOGRAPHY

During the year, Committee E-4 has held three meetings as follows: in Atlantic City on June 24, 1930, in New York City on February 17, 1931, and in Pittsburgh, on March 19, 1931.

The chairman appointed Mr. H. A. Anderson of the Western Electric Co., Inc., to succeed Mr. R. S. Dean as chairman of the special committee to obtain micrographs showing the spheroidization of high-speed steels.

Mr. C. J. Tobin has been appointed as chairman of a special committee to investigate the advisability of preparing grain size charts or standards for steel.

Committee E-9 on Correlation of Research referred to Committee E-4 the question of the desirability of undertaking an investigation of the influence of metallographic characteristics of metals and alloys upon the mechanical properties. The subject has been discussed at meetings of the committee and it has been agreed to cooperate in supplying information on the metallographic characteristics of materials upon the request of other committees of the Society.

On November 18, 1930, ballots were sent to the members of the committee relative to recommending the submission of the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 - 30) to the American Standards Association for approval as American Standard under the Proprietary Sponsorship Method of A.S.A procedure. Forty members returned their ballots; of whom 37 voted affirmatively, none negatively and 3 refrained from voting.

ACTIVITIES OF SUBCOMMITTEES

Subcommittee I on Selection and Preparation of Samples (E. H. Dix, Jr., chairman).—This subcommittee has continued its efforts to obtain a source of supply of polishing cloth. A cloth known as "kitten's ear broadcloth" stocked by the Horne Co. of Pittsburgh has been found to be generally satisfactory. Kersey cloth was reported as being in general use in some laboratories.

The use of sulfur as a mounting material for some specimens has been recommended.

This subcommittee still has under consideration the revision of the Standard Methods of Metallographic Testing of Iron and Steel (E 3 - 24) and the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 - 27).

Subcommittee II on Nomenclature and Definitions (Arthur Phillips, chairman).—The definition of the terms "grain," "alpha brass," and "beta brass" are under consideration.

Subcommittee IV on Photography (H. S. Rawdon, chairman).—This subcommittee is considering a revision of the Recommended Practice for Photography as Applied to Metallography appearing in the Standard Rules Governing the Preparation of Micrographs of of Metals and Alloys (E 2 - 30). It was voted at the meeting in Pittsburgh to recommend the use of an 8-mm. objective with the 7½X or other suitable eye piece for a magnification of 250 diameters. It was also voted that a magnification of 250 diameters be substituted for 200 diameters in the list of standard magnifications in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 - 30). A re-survey of the whole field of selection of lenses for different magnifications was requested of this subcommittee. This study will include the definition of the word "macrograph," as it is the opinion of several members that this term should include magnifications up to 20 or 25 diameters.

Subcommittee VI on X-ray Crystal Analysis (L. W. McKeehan, chairman).—The members of Subcommittee VI have been mutually helpful in the collection of information regarding methods and apparatus. Four new members have been added to this subcommittee.

G. L. Clark has been at work on the X-ray measurements on grain size, looking toward the preparation of a paper on this subject for presentation before the Society. H. H. Lester has been engaged in an X-ray study of welds.

The chairman has suggested that inasmuch as Subcommittee VI covers a broader field than the one implied by the present name the name of the subcommittee be changed to "Subcommittee on X-ray Methods." If this is acceptable and approved by the ballot on this report, the change of name will be effected.

This report has been submitted to letter ballot of the committee, which consists of 52 members; 38 members returned their ballots, of whom 36 have voted affirmatively and 1 negatively.

Respectfully submitted on behalf of the committee,

C. H. DAVIS,
Chairman.

O. E. HARDER,
Secretary.

REPORT OF COMMITTEE E-6

ON

PAPERS AND PUBLICATIONS

This annual report of Committee E-6 covers a wide activity in the field of Society papers and publications. The planning of the program of the annual meeting is always, of course, the item of greatest importance and is taken up first.

Program of 1931 Annual Meeting:

Probably the outstanding feature of the program for this meeting is the fact that it contains joint sessions with three societies: with the American Society of Mechanical Engineers in two sessions comprising the Symposium on Effect of Temperature on the Properties of Metals; with the American Foundrymen's Association in one session comprising the Symposium on Malleable Castings; and with the Western Society of Engineers in a session devoted to a discussion of "The Economic Significance of Specifications for Materials." In holding these joint sessions the Society recognizes the advantages of cooperation with its sister technical societies engaged in related fields of industry.

The Symposium on Effect of Temperature on the Properties of Metals is by far the largest effort of its kind ever undertaken by our Society. It was planned and carried through by the Joint A.S.M.E.-A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals; it constitutes an authoritative résumé of (1) engineering trends and requirements for metals at high and low temperatures and (2) properties of available metals for high- and low-temperature service. It comprises 28 papers published jointly by the two societies in a bound book of 620 pages. A novel plan of conducting the symposium is being tried, whereby none of the papers will be individually presented by their authors; instead the papers in each of the two groups will be summarized by two reviewers, following which the subject will be thrown open for general discussion.

The Papers Committee wishes to express its appreciation of the services rendered by the Joint Committee in the compilation of the symposium and particularly of the work of H. W. Gillett, a member of the Research Committee and chairman of the Symposium Committee.

The Symposium on Malleable Iron Castings is the first of several that have been planned by the American Foundrymen's Association and our Society for the purpose of providing the engineering profession with authoritative data in concise form on the properties of malleable castings produced by the best present methods of production. The field of malleable castings was chosen for this year's program and the general symposium has been in the charge of the following committee: R. E. Kennedy, W. P. Putnam, F. M. Robbins, H. A. Schwartz, Enrique Touceda, I. R. Valentine, O. B. Zimmerman and C. L. Warwick, chairman. Publication of the symposium is being undertaken jointly by the A.F.A. and A.S.T.M.

In 1932 it is planned to cover in this way the subject of steel castings, to be followed in subsequent years by gray iron and other iron castings; and castings of various non-ferrous metals and alloys.

The Society is particularly pleased at the opportunity that a meeting in Chicago has afforded of joining with the Western Society of Engineers in a program devoted to consideration of the economic significance of certain features of the work of the A.S.T.M. We have appreciated the hearty support that has been given by the Western Society of Engineers both in the development of the program and in arrangements for participation of members of the W.S.E.

There has been arranged under the sponsorship of the Society's Coordinating Committee on Weathering Characteristics of Masonry Materials (comprising representatives of five interested A.S.T.M. committees) a symposium on this subject, in which it has been sought to bring out available information on the weathering of masonry materials and to emphasize those phases which require further study and on which information is lacking.

Another committee of the Society has sponsored a feature of the program, namely, a Symposium on Abrasion Testing of Rubber, undertaken by Committee D-11 on Rubber Products. This symposium continues the work begun by this committee a year ago to stimulate the presentation before the Society of papers dealing with the testing and properties of rubber products.

In addition to these several features, the program contains reports from nearly all of the standing and research committees and from several sectional committees under A.S.A. procedure for which the A.S.T.M. is sponsor. The total number of reports on the program is 48.

The technical papers on the program, in addition to those already mentioned in connection with the several symposiums, cover many of the materials fields in which the Society is engaged, including cement and concrete, masonry building materials, corrosion and fatigue of metals, iron and steel, magnetics, paints, paving materials and testing.

The total number of papers is 84, making 132 items on the program. This number takes no account of quite a few technical papers relating specifically to committee activities that have been appended to the reports of respective committees. These have been listed separately on the program to the number of 13.

It has not been possible to preprint everything for the meeting, due partly to budgetary limitations and partly to the fact that quite a number of papers were received so late as not to leave adequate time for editing and publication. However, all but three committee reports have been printed, including all reports that contain any recommendations affecting standards and tentative standards. Since the entire success of the High-Temperature Symposium as it is to be presented depended on advance distribution of the papers, special effort was made to preprint these papers. Although their volume was much greater than was at first anticipated and some of the papers contained extensive and difficult tabular matter, the entire group of 28 papers was published and distributed on June 5.

As usual, the preprints were distributed to the members in advance of the meeting in two installments and a third installment is being distributed during the week of the meeting.

The following table gives statistical information on preprinting:

	REPORTS		PAPERS		TOTAL	
	NUMBER	PAGES	NUMBER	PAGES	NUMBER	PAGES
Preprinted	45	669	67	1168	112	1837
Not Printed	2	23	18	311	20	334
Total	47	692	85	1479	132	2171

Due to the presence of the High-Temperature Symposium the above figures dwarf even those of last year's annual meeting, the program of which contained 127 items, of which 106 were preprinted, comprising 1379 pages.

Papers for Pittsburgh Regional Meeting:

The papers for the second Regional Meeting of the Society held March, 1931, at Pittsburgh, constituted a Symposium on Welding planned jointly by the Pittsburgh District Committee and the Committee on Papers and Publications. The titles and authors of the eleven papers comprising the Symposium are given below:

General Survey of Welding Processes—F. T. Llewellyn.
Welding Processes Applicable to Aluminum—W. M. Dunlap.
The Quality of Materials for Fusion Welding—C. R. Texter and F. N. Speller.

Modern Application of Arc Welding—A. M. Candy.
Recent Developments in Gas Welding and Cutting—E. J. W. Egger.
Stethoscopic Examination of Welded Products—J. R. Dawson.
Tests of Welding Made by the Watertown Arsenal—G. F. Jenks.
Gamma Ray Testing of Welds—G. E. Doan.
Magnetic Methods of Testing Butt Welds—T. R. Watts.
Fatigue and Impact Testing of Welded Products—T. M. Jasper.
Welding Inspection—R. Kraus.

Of these eleven papers eight were printed in advance. All the papers with discussion will be reprinted in a single pamphlet of approximately 180 pages and sold to members at special prices.

Selected A.S.T.M. Standards for Students:

A year ago the committee reported in detail on the inauguration of the plan of publishing for the use of students in technical schools a selection of 24 specifications and methods of test representing a cross-section of A.S.T.M. standards that would seem to be of maximum usefulness for this purpose. Two printings of the first edition, totaling 3000 copies, were made in 1930, which it is expected will meet requirements for the balance of 1931. In planning the contents of the second edition, consideration is being given to a number of suggestions for modifications and enlargement that have been received by the committee.

The above selection of standards has comprised those of interest primarily to engineering students and to students taking courses in materials testing. A special committee of the Papers Committee, comprising C. S. Reeve, chairman, R. L. Hallett and A. W. Carpenter, has been at work during the year in planning a companion "student pamphlet" containing standards of more particular interest to students in chemistry, chemical engineering, metallurgy and allied fields. A provisional list of such standards totaling approximately 200 pages has been compiled and the committee is now engaged in consulting a number of professors of chemical engineering and of metallurgy concerning the acceptability of such a pamphlet for use in their courses. If favorable responses are received the pamphlet will probably be published towards the end of the year.

Regular Publications:

The regular publication activities carried on during the year are referred to in the annual report of the Executive Committee based upon information supplied by the Papers and Publications Committee.

Special mention, however, should be made of the new procedure now in effect whereby reports of committees presented to the Executive Committee between annual meetings of the Society may be printed at once and copies made available to all members of the Society who request them. During the past year two such reports, one from Committee A-1 on Steel and the other from Committee C-10 on Hollow Masonry Building Units, were printed and distributed.

In addition the Papers and Publications Committee publishes new tentative standards or amendments of existing tentative standards submitted by the standing committees between annual meetings and approved by Committee E-10 on Standards.

In the past year the following tentative standards were thus published:

Tentative Specifications for Structural Steel for Ships (A 131 – 31 T)
Tentative Specifications for Ferro-Molybdenum (A 132 – 31 T)
Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296–31 T)
Tentative Method of Test for Hardness of Rubber (D 314–31 T)

Papers Presented at Committee Meetings:

The following papers have been reported to the Papers Committee as having been presented at committee meetings during the year: At the meeting of Committee D-1 on Preservative Coatings for Structural Materials; Subcommittee VIII:

Recent Developments in the Mechanical Control of the Carbon Arc and Its Possible Application in Accelerated Weathering—M. J. Dorcas.
Comparison of the Results of Exposures of Some Varnishes, Lacquers and Enamels in Different Accelerated Weathering Units—W. R. Fuller.
Comparison of the Results of Exposures of Representative Oil Paints with Especial Reference to the Influence of the Type of Wood Used as a Test Panel—F. C. Schmutz.

At the meeting of Committee D-13 on Textile Materials in Boston on October 16 and 17:

The Newer Developments in Textile Microscopy—E. R. Schwarz.
Future Textile Laboratory Practice—G. B. Haven.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF. COMMITTEE E-8
ON
NOMENCLATURE AND DEFINITIONS

The past year in the work of Committee E-8 on Nomenclature and Definitions has seen the organization of two new subcommittees, one on Definition of Coke to harmonize definitions prepared by Committees D-5 on Coal and Coke and D-2 on Petroleum Products and Lubricants, and the second on Definitions of Net Calorific Value and Gross Calorific Value to prepare definitions for these terms as applied to the several types of fuels.

The Subcommittee on Definition of Brick has completed its work extending over the past few years looking toward the preparation of a definition for brick, which definition is submitted as information as a part of this report.

The tentative definitions of terms submitted at the last annual meeting of the Society have been reviewed by the Editorial Committee and comments have been forwarded to the standing committees concerned. Relatively few definitions are being recommended for advancement to standard this year which might well be expected to be the case in view of the large number advanced to standard at the annual meeting in 1930. At that meeting 88 definitions were adopted, all of them having been approved by Committee E-8, and one definition was withdrawn, which brings the total of standard definitions approved by Committee E-8 to 257.

The Glossary of Terms, which has been issued annually for the past few years, has continued to serve a very useful purpose and comprised one of the more important contributions made by Committee E-8.

New Subcommittees.—A Subcommittee on Definition of Coke has been organized under the chairmanship of Mr. H. C. Porter with the following personnel:

W. M. Saunders, representing Committee A-3 on Cast Iron
J. B. Rather, representing Committee D-2 on Petroleum Products and Lubricants
Prévost Hubbard, representing Committee D-4 on Road and Paving Materials
H. C. Porter, representing Committee D-5 on Coal and Coke

A definition for coke prepared by Committee D-5 on Coal and Coke had been published as a tentative definition of the Society.[1] This definition, however, was not considered sufficiently general and the subcommittee mentioned above was appointed to review the definition and to harmonize the several views concerning this definition. Excellent progress has been made to date although the subcommittee is not as yet prepared to present a final report.

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[1] See Tentative Definition of the Term Coke (D 121 – 30 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1147 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 472.

A Subcommittee on Definitions for Net Calorific Value and Gross Calorific Value was appointed as the result of a communication from the U. S. Committee of the World Power Conference suggesting that work be undertaken looking toward the securing of agreement on the interpretation of net calorific value and gross calorific value of various types of fuels. Standard definitions are the first prerequisite and the subcommittee was accordingly organized with this end in view. This subject is of interest to a number of major groups and they have accordingly been included on the committee. The complete personnel of the subcommittee functioning under the chairmanship of Mr. H. C. Porter is as follows:

W. J. Wohlenberg, representing the American Society of Mechanical Engineers
A. C. Fieldner, representing the U. S. Bureau of Mines
H. C. Dickinson, representing the U. S. Bureau of Standards
W. M. Saunders, representing Committee A-3 on Cast Iron
A. E. Flowers, representing Committee D-2 on Petroleum Products and Lubricants
H. C. Porter, representing Committee D-5 on Coal and Coke

Definition of Brick.—Several years ago a request was received from Committee C-3 on Brick that Committee E-8 prepare a definition for the term brick. A suggested wording was submitted. A definition for this term is of interest to several standing committees of the Society including Committee C-8 on Refractories, Committee D-4 on Road and Paving Materials (in view of its specifications for paving brick) and Committee C-3 on Brick. The representatives of these three committees serve with the three members of the Editorial Committee as a Subcommittee on Definition of Brick under the chairmanship of Mr. H. P. Tiemann. A proposed definition for the term brick was published as information in the annual reports of Committee E-8 for 1928 and 1929.[1] This was brought to the attention of the various interests concerned and comments solicited. A study was made of the literature in respect to the use of the term and the standard dictionaries were consulted as well as the tariff and traffic regulations. The definition given below was then prepared and reported to the Advisory Committee of Committee E-8, with a vote of 5 affirmative and 1 negative. The Advisory Committee voted to receive this report:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 679 (1928); also Vol. 29, Part I, p. 536 (1929).

> *Brick.*—In the case of structural and road building material, a small unit, solid or practically so, commonly in the form of a rectangular prism, formed from inorganic, non-metallic substances and hardened in its finished shape by heat or chemical action.
>
> NOTE.—The term is also used collectively for a number of such units, as "a carload of brick."
>
> In the present state of the art, the term brick, when used without a qualifying adjective, should be understood to mean such a unit, or a collection of such units, made from clay or shale hardened by heat. When other substances are used the term brick should be suitably qualified unless specifically indicated by the context.
>
> In the United States structural brick are usually 8 by $3\frac{3}{4}$ by $2\frac{1}{4}$ in. in size, but may also be of other size or shape.

This definition will come up for consideration at a meeting of Committee E-8 to be held during the annual meeting.

Glossary of Terms.—The Glossary of all terms appearing in the standards and tentative standards of the Society was again issued during the year in mimeographed form and was brought to the attention of all members of Committee E-8 and the officers of standing committees. It has further received wide distribution as a result of an announcement appearing in the A.S.T.M. BULLETIN that copies were available to all those interested.

The Glossary will again be issued in mimeographed form, containing all revisions resulting from actions taken at the annual meeting and the revised Glossary will again be brought specifically to the attention of the standing committees with the request that each standing committee comment on the definitions of any terms that would seem to be of interest in that committee, either suggesting modifications of the present definitions to make these definitions sufficiently broad so as to apply to the work of that committee, or where this is not feasible, suggesting alternate definitions.

In preparing new definitions the standing committees should, of course, consult the Glossary to see if the terms which it is proposed to define are already included in the Glossary.

DEFINITIONS APPROVED BY COMMITTEE E-8

The 88 terms approved at the 1930 annual meeting, bringing the total of standard definitions approved to 257, are listed below:

Advanced (or Typical) Decay
Annealing
Annual Ring
Bark Pocket
Beehive Coke
Blemish
Box Pile
By-Product Coke
Carburizing (Cementation)
Case Hardening
Check
Coke Breeze
Collapse
Common Iron
Compressive Strength
Cross Break
Cross-Grained Wood
Curly-Grained Wood
Cyaniding
Decay
Decayed Knot
Defect
Diagonal-Grained Wood
Dip-Grained Wood
Double-Refined Iron
Dry Coke
Encased Knot
End Check
Fagoting
Firm Red Heart
Full Annealing
Graphitizing
Gypsum Partition Tile or Block
Gypsum Pottery Plaster
Hardening
Heart Check
Heartwood
Heat Treatment
Honeycombing
Incipient Decay
Intergrown Knot
Interlocked-Grained Wood
Knot
Large Knot
Large Pitch Pocket
Loose Knot
Malleablizing
Medium Knot
Medium Pitch Pocket
Modulus of Elasticity
Normalizing
Patenting
Pin Knot
Pitch Pocket
Pitch Streak
Pith
Pith Knot
Process Annealing
Quenching
Refined Bar Iron or Refined Wrought-Iron Bars
Regain (Moisture Regain)
Round Knot
Sapwood
Shake
Slab Pile
Small Knot
Small Pitch Pocket
Sound Knot
Sound Wood
Spheroidizing
Spike Knot
Spiral-Grained Wood
Springwood
Strain
Stress
Stress-Strain Diagram
Structural Timber
Summerwood
Surface Check
Tempering (also termed Drawing)
Tensile Strength or Ultimate Tensile Strength
Through Check
Through Shake
Tight Knot
Wane
Water-Soak (or Stain)
Wavy-Grained Wood
Wrought Iron

DEFINITIONS RECOMMENDED FOR ADOPTION AS STANDARD

Two definitions that have been approved by Committee E-8 are being recommended for adoption as standard at this annual meeting, namely, the definitions for the terms "spalling" and "pyrometric cone equivalent," developed by Committee C-8 on Refractories. The definitions in the form in which they are being recommended for adoption appear in the Tentative Definitions of Terms Relating to Refractories (C 71 – 30 T).[1]

The definitions recommended for advancement to standard have been submitted to letter ballot of the committee with the following results:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1037 (1930); also 1930 Book of A.S.T.M. Tentative Standards, p. 204.

Items	Affirmative	Negative	Not Voting
I. Advancement to Standard of Tentative Definitions			
1. Definition for the Term "Spalling" (C 71 - 30 T)	16	1	9
2. Definition for the Term "Pyrometric Cone Equivalent" (C 71 - 30 T)	19	0	7

Tentative Definitions Before Committee E-8

As mentioned above, 88 tentative definitions were adopted as standard at the 1930 annual meeting. Twenty-five new tentative definitions were submitted as follows:

Conductance
Creosote Coal-Tar Solution
Creosote (Creosote-Oil)
Diamagnetic
Ferromagnetic
Film Resistance
Gypsum Sheathing Boards
High-Early-Strength Portland Cement
Linkage
Magnetic Circuit
Magnetic Potential Difference
Paramagnetic
Resistance
Surface Coefficient
Tar, Coal
Tar, Coal Gas (Gas-House Tar)
Tar, Coke-Oven
Tar, Water-Gas
Thermal Analysis
Thermal Conductivity
Thermal Resistivity
Thermoelectric Power
Total Resistance
Transmission
Transmittance

Grouped below according to subject matter, the present status of these definitions is indicated:

Terms Relating to Magnetic Testing (A 127).—The following terms were submitted by Committee A-6 on Magnetic Properties as a part of the Tentative Definitions Relating to Magnetic Testing (A 127):

Magnetic Circuit
Magnetic Potential Difference
Diamagnetic
Paramagnetic
Ferromagnetic
Linkage

Comments in respect to these definitions were forwarded to Committee A-6, which it is understood are acceptable to the committee.

Definition for Thermoelectric Power (B 77).—The Editorial Committe has reviewed the definition for "thermoelectric power" submitted by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys and has forwarded comments regarding it to the committee. Agreement has not been reached between Committee E-8 and Committee B-4 in respect to the wording of this definition and accordingly further consideration will be given to it during the coming year.

Term Relating to Cement (C 74).—A definition for "high-early-strength-portland cement" submitted by Committee C-1 on Cement has been reviewed by the Editorial Committee of Committee E-8 and comments forwarded to Committee C-1.

Terms Relating to Heat Transmission (*C 71*).—The following terms were submitted at the 1930 annual meeting by Committee C-8 on Refractories as a part of the Tentative Definitions of Terms Relating to Refractories (C 71):

Thermal Conductivity
Thermal Resistivity
Resistance
Conductance
Film Resistance
Surface Coefficient
Total Resistance
Transmittance
Transmission

Committee C-8 is recommending the advancement to standard of these definitions at this annual meeting. The Editorial Committee, upon reviewing these definitions, forwarded a number of comments to Committee C-8 at the same time suggesting that the definitions be continued as tentative for another year. Committee C-8 has this suggestion under consideration at the present time.[1]

Term Relating to Gypsum (*C 79*).—Committee C-11 on Gypsum submitted one new definition at the last annual meeting, namely, for "gypsum sheathing boards." This definition together with other definitions for gypsum are still under discussion with that committee.

Terms Relating to Timber Preservatives (*D 324*).—The following terms were submitted by Committee D-7 on Timber:

Creosote (Creosote Oil)
Creosote Coal-Tar Solution
Tar, Coal
Tar, Coal-Gas (Gas-House Tar)
Tar, Coke-Oven
Tar, Water-Gas

The Editorial Committee has reviewed these definitions since they parallel to some extent other definitions already before the Society, submitted by other standing committees. It is proposed to have these definitions and their related definitions reviewed by a subcommittee of Committee E-8.

Definition for Thermal Conductivity (*D 325*).—The Editorial Committee has reviewed the definition for "thermal conductivity" submitted by Committee D-9 on Electrical Insulating Materials and suggestions in respect to this definition are now under discussion between Committee E-8 and Committee D-9.

Definition for Thermal Analysis (*E 14*).—The definition for "thermal analysis" submitted by Committee E-4 on Metallography is still before Committee E-8 for consideration.

Approximately 100 additional definitions are being continued as tentative. Since no change is reported in the status of these definitions reference is made to the 1930 annual report of Committee E-8[2] for a list of these definitions.

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[1] The recommendation to advance these definitions to standard was withdrawn by Committee C-8.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 939 (1930).

DEFINITIONS PUBLISHED AS INFORMATION

Several standing committees of the Society included definitions with their annual reports in 1930, which were published as information prior to their submission to the Society for publication as tentative, as follows:

Terms Relating to Building Stone.—Committee D-18 on Natural Building Stones prepared definitions of an extensive list of terms which definitions appear with its 1930 report.[1] The terms defined are as follows:

Stone
Building Stone
Granite
Building Granite
Basalt
Limestone
Building Limestone
Oolitic Limestone
Dolomite
Marble
Building Marble
Decorative Marble
Quartzite
Sandstone
Building Sandstone
Building Slate or Argillite
Igneous Rock
Volcanic Rock
Sedimentary Rock
Metamorphic Rock
Trap Rock

Definitions for Waterproofing and Damp-proofing.—Committee D-8 on Bituminous Waterproofing and Roofing Materials included in its report for 1930 definitions for the terms "waterproofing" and "damp-proofing."

Definition for Gypsum Concrete.—A definition for the term "gypsum concrete" appeared in a report on the Properties of Gypsum Fiber Concrete appended to the 1930 annual report of Committee C-11.

Terms Relating to Metallography.—Committee E-4 on Metallography published as information a definition for the term "plasticity" as relating to metals and a definition for the term "fiber in metals."

All of these definitions have received the attention of the Editorial Committee during the year and comments concerning a number of them have been brought to the attention of the standing committees concerned. Committee E-8 welcomes the reference of definitions to it while these definitions are still in the subtentative status since opportunity is thus afforded to have the definitions reviewed and put in standard form prior to their publication as tentative.

This report has been submitted to letter ballot of the committee, which consists of 48 members; 29 members returned their ballots, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 894 (1930); see also p. 845.

REPORT OF COMMITTEE E-9
ON
CORRELATION OF RESEARCH

The Committee on Correlation of Research presents in this its seventh annual report a brief review of some of the research developments in the Society during the past year. A more comprehensive review of all research projects in the Society will, in accordance with the plans announced a year ago, appear in the A.S.T.M. Bulletin this coming October. This review will be along the lines of the reviews published in the October and December, 1930, Bulletins.

Research Committee Activities:

The Research Committee on Yield Point of Structural Steel has extended its work by a study of the relation of rate of strain of specimens to speed of head of testing machine and is submitting some interesting results in its report this year.

The Research Committee on Fatigue of Metals is continuing its publication of abstracts of articles on fatigue of metals appearing in various publications, both American and foreign, and is continuing its summary of the present-day knowledge of fatigue. For the next year it plans to emphasize a summary of our knowledge of corrosion-fatigue and a discussion of the significance of fatigue test results to the structural engineer and machine designer.

The Joint A.S.M.E.-A.S.T.M. Research Committee on Effect of Temperature on the Properties of Metals has carried forward its research program and is reporting to its sponsor societies this June the results of studies of the fatigue properties of low-carbon steel at elevated temperatures, carried out at the University of Illinois under the guidance of the committee. The Joint Committee's report to the two sponsor societies includes a report on these tests and also two papers on methods of testing at low temperatures and at elevated temperatures. The Symposium on Effect of Temperature on the Properties of Metals, which comprises two sessions of the annual meeting, held jointly with the American Society of Mechanical Engineers, has been sponsored by this Joint Committee in the interest of promoting knowledge of this important subject and providing means for an interchange of information and coordination of activities in this field. The Joint Committee is continuing its efforts to provide adequate financial support for its research program.

Other Research Activities of the Society:

The research on causes of embrittlement on hot-dipped galvanized structural steel under the auspices of Committee A-5 on Corrosion of Iron and Steel, mentioned in the report a year ago, has been carried on actively at Battelle Memorial Institute, Columbus, Ohio, which was retained by the committee to carry on this work under its general direction. This research has been coordinated with a similar project at Battelle Memorial Institute sponsored by the Utilities Research Commission. The details of the arrangement are announced in the annual report of Committee A-5.

In the general field of research in mineral aggregates, the outstanding event of interest is the placing of this project under the auspices of the Highway Research Board of the National Research Council. The various interests concerned with mineral aggregates have agreed on the advantages of coordinating their studies in this field through the Highway Research Board. A joint committee has been formed, and through the interest of the Bureau of Public Roads an engineer has been assigned to the work of the committee and funds to meet miscellaneous expenses are being contributed by the various interested groups; Committee E-9 has contributed $300 from the A.S.T.M. Research Fund for this purpose.

Periodic Review of Certain Technical Literature:

The review by the Research Committee on Fatigue of Metals of articles appearing in various publications throughout the world and the annual publication of abstracts of such articles has met with such favorable response that periodic critical review of the literature in other fields has been seriously suggested. One such suggestion recorded in the report a year ago related to the literature on corrosion of iron and steel and is being considered by Committee A-5 on Corrosion of Iron and Steel. Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys has been asked to consider the possibilities of this idea with respect to articles on corrosion of non-ferrous metals and alloys; while a similar proposal relating to the literature on the properties of metals at low and high temperatures is under consideration in the Joint Research Committee on that subject. The thought has been advanced that the annual publication of critical abstracts in these three somewhat related fields of corrosion, fatigue, and high- and low-temperature properties of metals would be of much practical value and that their publication could be put upon a self-sustaining basis. The practical success of the plan depends upon the ability to provide for the necessary reviews of the literature under the auspices of the several interested committees.

Committee A-8 on Magnetic Analysis is considering a similar review of the literature in its field.

Possible Important Lines of Research:

The following lines of research, which have been called to the committee's attention during the year, seem to give promise of importance:

1. The nature and effects of and tests for brittleness.
2. What constitutes a good bearing metal?
3. The effect of size distribution of particles on the concrete-making properties of cement.
4. The significance and effect of stresses caused by shrinkage, especially in concrete.
5. Properties of and tests for heat-insulating materials and sound-insulating materials.
6. General studies of the following materials: slate, lime, leather, textiles, refractories and paper.

In some cases, these suggested studies have been referred to existing committees. In other cases there is need for research, but no definite agency to which the matter can be referred. This is especially true in the case of paper and of leather, although it is of interest to note that the Executive Committee of the Society has recently authorized the organization of a standing Committee on Paper.

Miscellaneous Administrative Matters:

The appointment in June, 1930, of H. F. Moore to serve as a member of the committee for another term of five years is reported. Mr. Moore was re-elected to serve as chairman of the committee.

The term of office of George K. Burgess as a member of the committee expires at the annual meeting this year; the appointment of his successor will be made by the Executive Committee of the Society.

The principal of the A.S.T.M. Research Fund is at present $8387.85. The balance of income reported a year ago as of April 10, 1930, was $578.12. Receipts since then have totaled $540, representing interest on investments. Disbursements have comprised $40.80 to the Research Committee on Yield Point of Structural Steel for miscellaneous expenses, $300 to the Joint Committee on Mineral

Aggregates of the Highway Research Board and $500 towards certain studies of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel, leaving a balance on June 15, 1931, of $277.32.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

C. L. WARWICK,
Secretary.

REPORT OF COMMITTEE E-10

ON

STANDARDS

Committee E-10 on Standards had a very active year. Two meetings were held during the year, both in Philadelphia, Pa., one on August 12, 1930, and the other on February 20, 1931. A number of standing committees have taken advantage of the procedure for submitting to the Society in the interval between annual meetings new tentative standards or revisions of tentative standards whereby these are reviewed by Committee E-10 and accepted for publication during the year. A number of projects came up for consideration resulting in steps being taken looking toward the organization of new standing committees. The committee has been in responsible charge of the submission of A.S.T.M. standards to the American Standards Association for approval as American Standard or American Tentative Standard.

The activities of the committee during the year are set forth in this report under the following heads: review of A.S.T.M. standardization activities, consideration of new and revised tentative standards, relations with American Standards Association, and promotion and expansion of standardization activities.

Review of A.S.T.M. Standardization Activities:

A general summary of the new tentative standards submitted at the 1930 annual meeting, of tentative standards advanced to standard and of revisions in standards was included in the July issue of the A.S.T.M. Bulletin. A further reference to the standardization work of the committees together with statements concerning new standards in prospect was given in the October Bulletin. It is proposed to publish such reviews annually in the July Bulletin. Much of the information, particularly in respect to standardization projects in development in committees, is furnished by the standing committees subsequent to the annual meeting and takes advantage of the fact that many committees plan their next year's work at committee meetings held during the annual meeting.

At the present writing it is possible to make only an approximate estimate in terms of new and revised standards of the volume of standardization work accomplished during the year and reported to the Society at this meeting. The reports of standing committees to be presented at the annual meeting include recommendations to the Society substantially as follows:

New tentative standards	36
Tentative revisions of existing standards	29
Revisions of tentative standards	26
Tentative standards recommended for advancement to standard	19
Revisions of existing standards recommended for adoption as standard	15
Standards and tentative standards withdrawn	1

There are at present 427 standards and 157 tentative standards of the Society making a total of 584, and if the above recommendations are approved this total will become 619.

Consideration of New and Revised Tentative Standards:

A number of standing committees have submitted to Committee E-10 during the year new tentative standards and revisions of existing tentative standards. The details of the procedure for such recommendations on tentative standards in the interval between annual meetings are set forth in the By-laws of the Society and in the Regulations Governing Standing Committees, Section 15.[1]

Committee E-10 on receiving such recommendations from the standing committees reviews them principally to insure that a substantial consensus has been reached in the standing committee concerned. It requires that the complete vote be recorded, analyzed according to producers, consumers, and general interests. If there are any negative votes the names of those voting in the negative must be recorded together with the reasons for so voting. The usual report of the standing committee is required, setting forth the needs for having the standard, that is, whatever demand may have prompted the committee in preparing it and also on what material the standard is based, that is, whether it is based upon standards already in existence or on work carried out by the committee, etc.

Proposed new standards that were approved by Committee E-10 and published as tentative during the year are as follows:

Tentative Specifications for Structural Steel for Ships (A 131 – 31 T), submitted by Committee A-1 on Steel;

Tentative Specifications for Ferro-Molybdenum (A 132 – 31 T), submitted by Committee A-9 on Ferro-Alloys;

Tentative Method of Compression Testing of Natural Building Stone (D 326 – 30 T), submitted by Committee D-18 on Natural Building Stones;

Tentative Method of Flexure Testing of Natural Building Stone (D 327 – 30 T), submitted by Committee D-18 on Natural Building Stones;

Tentative Method of Test for Absorption and Apparent Specific Gravity of Natural Building Stone (D 328 – 30 T), submitted by Committee D-18 on Natural Building Stones.

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[1] 1931 A.S.T.M. Year Book, p. 276.

Revisions of the following tentative standards were also approved by Committee E-10 and the tentative standards issued in their revised form during the year:

Tentative Specifications for Copper-Base Alloys in Ingot Form for Sand Castings (B 30 – 30 T), submitted by Committee B-5 on Copper and Copper Alloys, Cast and Wrought;

Tentative Specifications for Aluminum-Base Alloy Castings (B 26 – 30 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought;

Tentative Specifications for Aluminum-Base Casting Alloys in Ingot Form (B 58 – 30 T), submitted by Committee B-7 on Light Metals and Alloys, Cast and Wrought;

Tentative Specifications for Concrete Aggregates (C 33 – 30 T), submitted by Committee C-9 on Concrete and Concrete Aggregates;

Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (D 268 – 30 T), submitted by Committee D-1 on Preservative Coatings for Structural Materials;

Tentative Specifications and Tests for Soluble Nitrocellulose (D 301 – 30 T), submitted by Committee D-1 on Preservative Coatings for Structural Materials;

Tentative Specifications for Amyl Alcohol (Synthetic) (D 319 – 30 T), submitted by Committee D-1 on Preservative Coatings for Structural Materials;

Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 31 T), submitted by Committee D-11 on Rubber Products;

Tentative Method of Test for Hardness of Rubber (D 314 – 31 T), submitted by Committee D-11 on Rubber Products;

Tentative Specifications for Tolerances and Test Methods for Rayon (D 258 – 31 T), submitted by Committee D-13 on Textile Materials.[1]

In addition to the new and revised tentative standards which were approved, three proposed tentative standards and one proposed revision of a tentative standard were submitted to Committee E-10 concerning which the committee was not satisfied that it could approve them on the basis of the information furnished and which were accordingly referred back to the standing committees concerned, as follows:

Proposed Tentative Specifications for Rubber Pump Valves, submitted by Committee D-11 on Rubber Products;

Proposed Tentative Method of Determining Relative Humidity, submitted by Committee D-13 on Textile Materials;

Proposed Definitions of Terms Relating to Natural Building Stone, submitted by Committee D-18 on Natural Building Stones.[2]

Proposed revision of Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 – 28 T).

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[1] Publication of these revised specifications was deferred since additional changes were submitted by Committee D-13 shortly after the acceptance of the earlier revisions in view of which it was considered advisable to have all the revisions made at one time rather than to have several versions of the specifications.

[2] These definitions were subsequently published as information and appear as an appendix to the 1930 report of Committee D-18, see *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 894 (1930).

Mention should also be made of interim reports presented to the Executive Committee by Committee A-1 on Steel indicating that the committee planned to recommend certain revisions in the Standard Specifications for Billet-Steel Concrete Reinforcement Bars (A 15 – 30), and by Committee C-10 on Hollow Masonry Building Units indicating that the committee planned to recommend revisions at the approaching annual meeting of the Society in respect to several of its standard specifications for tile.

Relations with American Standards Association:

Committee E-10 has followed the Society's relations with the American Standards Association, with particular reference to standards submitted to the A.S.A. for approval. Such standards fall in one of two categories, standards submitted on the recommendation of a sectional committee for which the Society is sponsor or joint sponsor, and standards that have not been considered by a sectional committee but which are submitted for approval under the proprietary sponsorship method. The latter method is particularly applicable to many A.S.T.M. standards since it contemplates approval by the A.S.A. of standards in respect to which it can be shown that they have been developed in such a way that the interests of all concerned have been adequately considered and that the standards are generally acceptable to and in use by industry. The standards approved during the year are listed below:

STANDARDS SUBMITTED AND APPROVED UNDER SECTIONAL COMMITTEE PROCEDURE

On the Recommendation of the Sectional Committee on Petroleum Products and Lubricants:

Standard Method of Test for Saponification Number (D 94 – 28), American Standard;

Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (D 86 – 30), American Standard;

Standard Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge (D 96 – 30), American Standard;

Standard Method of Test for Burning Quality of Mineral Seal Oil (D 239 – 30), American Standard;

Standard Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 – 30), American Standard;

Standard Method of Test for Burning Quality of Kerosine Oils (D 187 – 30), American Standard;

Standard Method of Test for Distillation of Natural Gas Gasoline (D 216 – 30), American Standard;

Standard Method of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 30), American Standard;

Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (D 95 – 30), American Standard;

Standard Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline (D 130 – 30), American Standard;

Standard Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 30), American Tentative Standard;

Standard Method of Test for Melting Point of Petrolatum (D 127 – 30), American Tentative Standard;

Standard Method of Test for the Determination of Autogeneous Ignition Temperatures (D 286 – 30), American Tentative Standard.

On the Recommendation of the Sectional Committee on Methods of Testing Road and Paving Materials:

Standard Method of Test for Determination of Bitumen (D 4 – 27), American Standard;

Standard Method of Test for Penetration of Bituminous Materials (D 5 – 25), American Standard;

Standard Method of Float Test for Bituminous Materials (D 139 – 27), American Standard;

Standard Method of Test for Toughness of Rock (D 3 – 18), American Standard;

Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (D 75 – 22), American Standard.

On the recommendation of the Sectional Committee on Cement:

Standard Specifications for Portland Cement (C 9 – 30), American Standard;
Standard Methods of Testing Cement (C 77 – 30), American Standard.

On the Recommendation of the Sectional Committee on Zinc Coating of Iron and Steel:

Standard Specifications for Zinc-Coated (Galvanized) Sheets (A 93 – 27), American Tentative Standard.

Standard Specifications for Zinc (Hot-Galvanized) Coatings on Structural Steel Shapes, Plates, Bars and Their Products (A 123 – 30), American Tentative Standard.

On the Recommendation of the Sectional Committee on Cotton Rubber-Lined Fire Hose:

Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public and Private Fire Department Use (D 296 – 31 T), American Tentative Standard.

STANDARDS SUBMITTED AND APPROVED UNDER PROPRIETARY SPONSORSHIP METHOD

Standard Specifications for Refined Wrought-Iron Bars (A 41 – 30), submitted by Committee A-2 on Wrought Iron as American Tentative Standard;

Standard Specifications for Wrought-Iron Plates (A 42 – 30), submitted by Committee A-2 on Wrought Iron as American Tentative Standard;

Standard Methods of Routine Analysis of White Pigments (D 34 – 30), submitted by Committee D-1 on Preservative Coatings for Structural Materials as American Standard;

Standard Methods of Routine Analysis of Dry Red Lead (D 49 – **29**), submitted by Committee D-1 on Preservative Coatings for Structural Materials as American Standard;

Standard Methods of Laboratory Sampling and Analysis of Coal and Coke (D 271 – 30), submitted by Committee D-5 on Coal and Coke as American Standard;

Standard General Methods of Testing Woven Textile Fabrics (D 39 – 27), submitted by Committee D-13 on Textile Materials as American Standard.

The following standards have been referred to the American Standards Association but have not as yet been approved:

Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 – 27), under proprietary sponsorship method;

Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 – 24), under proprietary sponsorship method.

In addition to standards that have been formally submitted to the A.S.A. a number of standards have been recommended by the standing committees concerned for submission under the proprietory sponsorship method. These standards, which have not as yet gone forward to the A.S.A., are as follows:

Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 30), on the recommendation of the Committee A-2 on Wrought Iron;

Standard Specifications for Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars (A 73 – 30), on the recommendation of Committee A-2 on Wrought-Iron;

Standard Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 30), on the recommendation of Committees A-1 on Steel and A-2 on Wrought Iron;

Standard Specifications for Hollow Rolled Staybolt Iron (A 86 – 30), on the recommendation of Committee A-2 on Wrought Iron;

Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 – 27), on the recommendation of Committee C-9 on Concrete and Concrete Aggregates;

Standard Specifications for Gypsum (C 22 – 25), on the recommendation of Committee C-11 on Gypsum;

Standard Specifications for Calcined Gypsum (C 23 – 30), on the recommendation of Committee C-11 on Gypsum;

Standard Specifications for Gypsum Plasters (C 28 – 30), on the recommendation of Committee C-11 on Gypsum;

Standard Specifications for Gypsum Molding Plaster (C 59 – 30), on the recommendation of Committee C-11 on Gypsum;

Standard Specifications for Gypsum Pottery Plaster (C 60 – 30), on the recommendation of Committee C-11 on Gypsum;

Standard Specifications for Friction Tape for General Use for Electrical Purposes (D 69 – 28), on the recommendation of Committee D-11 on Rubber Products;

Standard Specifications for Rubber Matting for Use Around Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground (D 178 – 24), on the recommendation of Committee D-11 on Rubber Products;

Standard Methods of Verification of Testing Machines (E 4 – 27), on the recommendation of Committee E-1 on Methods of Testing;

Standard Methods of Brinell Hardness Testing of Metallic Materials (E 10 - 27), on the recommendation of Committee E-1 on Methods of Testing;

Rules Governing the Preparation of Micrographs of Metals and Alloys, Including the Recommended Practice for Photography as Applied to Metallography (E 2 - 30), on the recommendation of Committee E-4 on Metallography.

Sectional Committee Personnel.—No new sectional committees have been organized during the year. The Society has, however, accepted joint sponsorship with the U. S. Bureau of Standards for the organization of a Sectional Committee on Testing Sieves. A number of changes have been made in the Society representation on sectional committees either under Society sponsorship or joint sponsorship or on sectional committees under other sponsorship. New appointments and changes in representation are recorded currently in the A.S.T.M. Bulletin.

Promotion and Expansion of Standardization Activities:

Several important projects comprising new standardization activities came up for consideration in Committee E-10 during the year. Two of them have resulted definitely in the authorization of new standing committees and several may lead to the organization of new committees.

Committee on Water Analysis.—The Joint Committee on Boiler Feed Water Studies, on which the Society is represented, had proposed the organization of a subcommittee of the joint committee to formulate methods of water analysis. It was later suggested, however, that the project be undertaken by the Society through the organization of a new standing committee. After thorough consideration, Committee E-10 recommended the organization of a Committee on Water Analysis and the Executive Committee has approved the formation of such a standing committee. Steps are now being taken looking toward its organization.

Committee on Paper and Allied Products.—It was thought to be desirable for the sake of completeness that the Book of A.S.T.M. Standards contain methods of test for paper, taking full account of the work that the Technical Association of the Pulp and Paper Industry has already done in this field. Heretofore, the only phase of this subject under consideration by the Society was the work on electrical insulating and condenser papers. Discussions with T.A.P.P.I. had indicated that that association would welcome the cooperation of the Society in developing standards for this material and on the recommendation of Committee E-10, the Executive Committee approved the formation of a standing committee on Paper and Allied Products. Steps are now being taken looking toward the organization of this committee.

Heat Insulation.—The proposal has been made on a number of occasions that the Society give consideration to standards relating to heat insulation. This in itself is a rather broad field including not only insulation such as pipe covering but also other types of insulation such as used in refrigeration and in residence and general construction work. Committee E-10 is reviewing the field to determine the extent of the demand for standards relating to heat transmission and insulation and what form of organization could best handle this work. Two phases are already receiving consideration, one in the Society's Committee C-8 on Refractories, and the other in Committee D-9 on Electrical Insulating Materials, the work of the latter committee involving to some extent heat insulation as well as electrical insulation.

Acoustical Properties.—The developments that have taken place recently in the acoustical field have been reflected in certain demands that the Society undertake work on acoustical materials. This again is rather a broad field and will require considerable study in order to determine in what way the Society might best be of service.

Foundry Sands.—The committee still has before it a request from the American Foundrymen's Association that the Society give consideration to standard methods of testing foundry sands and specifications in this field, particularly with respect to the methods developed by a committee of the American Foundrymen's Association. No decision has as yet been reached as to how this work should proceed.

Soils.—The committee received a request from Committee D-4 on Road and Paving Materials that the Society appoint a committee on soils, subgrades, fills, back-fills and foundations. A great deal of research work has been done on this subject by the U. S. Bureau of Public Roads while the American Society of Civil Engineers for the past four years has had a Research Committee on Earths and Foundations. Committee E-10 has decided to investigate this subject further before making any recommendations.

Die-Steels.—The work of Committee B-6, formerly Subcommittee XV of Committee B-2, on Die-Cast Metals and Alloys indicated the desirability of giving consideration to specifications for die-steels. A joint committee has accordingly been organized consisting of three representatives from Committee B-6 and three representatives from Committee A-1 on Steel which joint committee will determine what work should be undertaken and how this work should proceed.

Wire and Wire Rope.—In view of a number of inquiries that have been received in respect to specifications for wire and wire rope, Committee A-1 on Steel has appointed a fact-finding committee to determine if any work might profitably be undertaken on this subject.

Miscellaneous.—A number of instances have developed during the year, either through a review of the Society's specifications or as a result of inquiries received, indicating the desirability of an A.S.T.M. standard in respect to some product or subject not yet covered. Suggestions in respect to these were transmitted to the standing committees concerned, as for example, specifications for cinder concrete, which question was referred to the Society's Committee C-9 on Concrete and Concrete Aggregates and to the Joint Committee on Specifications for Concrete and Reinforced Concrete.

Marking of Testing Apparatus:

In a number of instances where committees of the Society have developed specifications for testing apparatus, requirements have been included that the apparatus be marked in a manner identifying it with the Society's standard, a typical illustration being the "A.S.T.M. High-Distillation Thermometer." The Scientific Apparatus Makers of America recommended that in all such cases it should also be required that the name or trade mark of the manufacturers of such apparatus be marked thereon as a means of identifying the origin of the apparatus and placing the name of the manufacturer back of the statement that the apparatus conforms to Society standards. On the recommendation of Committee E-10, the Executive Committee has adopted the following resolutions as set forth in its report:

> RESOLVED, that where the specifications of the Society require that apparatus be marked in some way with the initials "A.S.T.M." it also be required that the name or trade mark of the manufacturer be marked on the apparatus, with the understanding that this requirement need not apply where apparatus specified by the Society is not required to be marked as "A.S.T.M." apparatus; further
>
> RESOLVED, that the attention of standing committees be called to the desirability, where requirements for apparatus are specified, of specifying that such apparatus be marked to identify it as A.S.T.M. apparatus, including the manufacturer's name or trade mark.

There has also been proposed to Committee E-10 that consideration be given to the preparation of a form of certification that manufacturers might issue with testing apparatus conforming to A.S.T.M. standards. This matter will receive attention during the year.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

A.S.T.M.
TENTATIVE STANDARDS

ISSUED OR REVISED, 1931

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action toward its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee, whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL STEEL FOR SHIPS[1]

A.S.T.M. Designation: A 131 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

MANUFACTURE

Process.

1. The steel shall be made by either or both of the following processes: open-hearth or electric-furnace.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

2. The steel shall conform to the following requirements as to chemical composition:

		STRUCTURAL STEEL AND STEEL FOR COLD BENDING	RIVET STEEL
Phosphorus	Acid	not over 0.06 per cent	not over 0.06 per cent
	Basic	" " 0.04 "	" " 0.04 "
Sulfur		" " 0.06 "	" " 0.045 "

Ladle Analyses.

3. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis should be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and the percentages of phosphorus and sulfur shall conform to the requirements specified in Section 2.

Check Analyses.

4. Analyses may be made by the purchaser from finished material representing each melt. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Structural Steel for Ships (A.S.T.M. Designation: A 12 – 21) and Standard Specifications for Rivet Steel for Ships (A.S.T.M. Designation: A 13 – 24), 1930 Book of A.S.T.M. Standards, Part I, pp. 98 to 107.

[2] Accepted for publication as tentative by Committee E-10 on Standards, February 20, 1931.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

5. (*a*) The material shall conform to the following requirements as to tensile properties:

	STRUCTURAL STEEL	RIVET STEEL AND STEEL FOR COLD BENDING
Tensile Strength, lb. per sq. in.	60 000 to 72 000	55 000 to 65 000
Yield Point, minimum, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
but in no case less than	33 000	30 000
Elongation in 8 in., minimum, per cent	$\frac{1\,500\,000^a}{\text{Tens. str.}}$	$\frac{1\,500\,000^a}{\text{Tens. str.}}$
Elongation in 2 in., minimum, per cent	22	....

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[a] See Section 6.

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Modification in Elongation.

6. (*a*) For material over $\frac{3}{4}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 5(*a*) of 0.25 per cent, shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness or diameter above $\frac{3}{4}$ in. to a minimum of 16 per cent for the structural grade and 18 per cent for the rivet steel and cold bending grade.

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter a deduction from the percentage of elongation in 8 in. specified in Section 5(*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. in thickness or diameter below $\frac{5}{16}$ in.

Bend Tests.

7. (*a*) *Structural Steel.*—Bend test specimens for structural steel shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion as follows: For material $\frac{3}{4}$ in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; for material over $\frac{3}{4}$ in. to and including $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen; and for material over $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen.

(*b*) *Rivet Steel and Steel for Cold Bending.*—Bend test specimens for rivet steel and steel for cold bending shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion as follows: For material $\frac{3}{4}$ in. or under in thickness, flat on itself; for material over $\frac{3}{4}$ in. to and including $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over $1\frac{1}{4}$ in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Test Specimens.

8. (*a*) Test specimens shall be prepared for testing from the material in its rolled condition, except as specified in Paragraphs (*b*) and (*c*).

(*b*) Test specimens for annealed material shall be prepared from the material as annealed for use, or from a short length of a full section similarly treated.

(*c*) Test specimens for rivet bars which have been cold-drawn shall be normalized before testing.

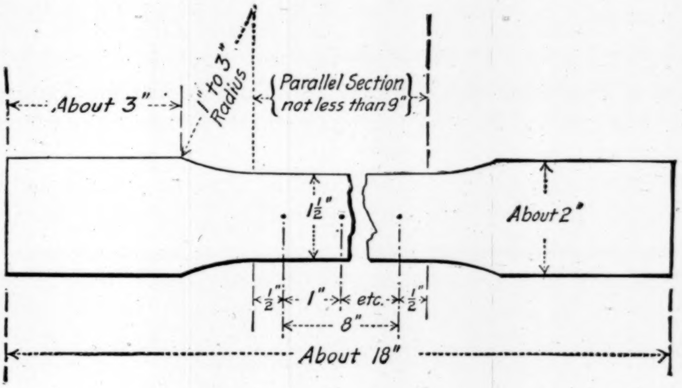
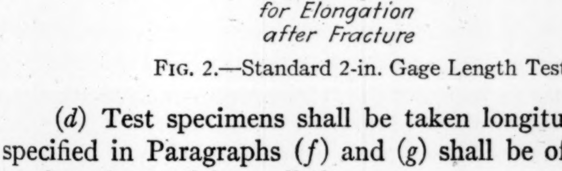

About 3"
1" to 3" Radius
Parallel Section not less than 9"
$1\frac{1}{2}$"
About 2"
$\frac{1}{2}$"
1"
etc.
$\frac{1}{2}$"
8"
About 18"

Fig. 1.—Standard 8-in. Gage Length Test Specimen.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

Fig. 2.—Standard 2-in. Gage Length Test Specimen.

(*d*) Test specimens shall be taken longitudinally and except as specified in Paragraphs (*f*) and (*g*) shall be of the full thickness or section of material as rolled.

(*e*) Test specimens for plates, shapes and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*f*) Tension test specimens for material over $1\frac{1}{2}$ in. in thickness or diameter may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in. or they may conform to the dimensions shown in Fig. 2.

(*g*) Bend test specimens for material over $1\frac{1}{2}$ in. in thickness or diameter may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. or to 1 by $\frac{1}{2}$ in. in section.

(*h*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests.

9. (*a*) Two tension and, except as specified in Paragraph (*b*), two bend tests shall be made from each melt of structural steel and steel for cold bending unless the finished material from a melt is less than 25 short tons, when one tension and one bend test shall be sufficient. Two tension and two bend tests shall be made from each melt of rivet steel. If the material from one melt varies 0.150 in. or more in thickness, the thickest and thinnest material rolled shall each be represented by one tension and one bend test, regardless of the weight of the melt.

(*b*) When material is ordered for cold bending and subject to ship classification societies' test and inspection, one bend test shall be required from each plate as rolled.

(*c*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*d*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5(*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND DIMENSIONS

Permissible Variations.

10. (*a*) One cubic inch of rolled steel is assumed to weigh 0.2833 lb. The cross-sectional area or weight of each structural size shape and of each universal mill plate up to and including 36 in. in width shall not vary more than 2.5 per cent from the theoretical or specified amounts. The thickness or weight of rectangular sheared mill plates and of rectangular universal mill plates over 36 in. in width shall conform to the requirements of Paragraphs (*b*) and (*c*). The cross-sectional area or weight of bar size[1] angles, tees, zees and channels shall conform to the requirements of Paragraph (*d*), and the cross-sectional dimensions of bars shall conform to the requirements of Paragraph (*e*).

(*b*) *Sheared Plates and Universal Mill Plates Over 36 in. in Width when Ordered to Weight per Square Foot:* The weight of each lot[2]

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[1] A channel is of "bar" size when its greatest dimension is less than 3 in. An angle, tee, or zee is of "bar" size when its greatest dimension is less than 3 in.; or when it is 3 in. or more and at the same time the thickness is less than $\frac{1}{4}$ in.

[2] The term "lot" as applied to Table I means all of the plates of each group width and group weight; as applied to Table II, it means all of the plates of each group width and group thickness.

Table I.—Permissible Variations of Rectangular Plates Ordered to Weight.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights.																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

Note.—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third the amount given in this table.

Table II.—Permissible Overweights of Rectangular Plates Ordered to Thickness.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	....	....	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl.	8	9	10	12	....	....	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	....	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

Note.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

in each shipment shall not vary from the weight ordered more than the amount given in Table I.

(*c*) *Sheared Plates and Universal Mill Plates Over 36 in. in Width When Ordered to Thickness:* The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[1] of plates in each shipment shall not exceed the amount given in Table II.

TABLE III.—PERMISSIBLE VARIATIONS IN WEIGHT OF BAR SIZE ANGLES, TEES, ZEES AND CHANNELS.

Dimensions	Thickness, in.	Variations, Expressed in Percentages of Nominal Weights
Any dimension over $1\frac{1}{2}$ in.	Over $\frac{3}{16}$	4 over and under
All dimensions $1\frac{1}{2}$ in. and less	Over $\frac{3}{16}$	5 " " "
Any dimension over $1\frac{1}{2}$ in.	$\frac{3}{16}$ and less	6 " " "
All dimensions $1\frac{1}{2}$ in. and less	$\frac{3}{16}$ and less	7 " " "

TABLE IV.—PERMISSIBLE VARIATIONS IN CROSS-SECTIONAL DIMENSIONS OF ROUNDS, SQUARES AND HEXAGONS.

Dimensions	Variations, in.	
	Over	Under
Up to and including $\frac{1}{2}$ in.	0.007	0.007
Over $\frac{1}{2}$ up to and including 1 in.	0.010	0.010
Over 1 up to and including 2 in.	$\frac{1}{32}$	$\frac{1}{64}$
Over 2 up to and including 3 in.	$\frac{3}{64}$	$\frac{1}{32}$
Over 3 up to and including 5 in.	$\frac{3}{32}$	$\frac{1}{32}$
Over 5 up to and including 8 in.	$\frac{1}{8}$	$\frac{1}{16}$

(*d*) The weight of each lot[2] of bar size angles, tees, zees and channels in each shipment shall not vary from the weight ordered more than the amounts given in Table III.

(*e*) The cross-sectional dimensions of bars shall not vary from the size ordered more than the amounts given in Tables IV and V.

FINISH

Finish. 11. The finished material shall be free from injurious defects and shall have a workmanlike finish.

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[1] The term "lot" as applied to Table I means all of the plates of each group width and group weight; as applied to Table II, it means all of the plates of each group width and group thickness.

[2] The term "lot" as applied to Table III means all of the bars of each group dimension and group thickness.

MARKING

Marking. 12. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material, except that rivet bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The melt number shall be legibly marked by stamping, if practicable, on each test specimen.

INSPECTION AND REJECTION

Inspection. 13. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

TABLE V.—PERMISSIBLE VARIATIONS IN CROSS-SECTIONAL DIMENSIONS OF FLATS.

Dimensions	Variations in Width, in.		Variations in Thickness, Over and Under from Thickness Specified, in.			
	Over	Under	$\frac{3}{16}$ in. and Under	Over $\frac{3}{16}$ in. up to $\frac{1}{2}$ in., inclusive	Over $\frac{1}{2}$ in. up to 1 in., inclusive	Over 1 in. up to 2 in., inclusive
Up to and including 1 in	$\frac{1}{32}$	$\frac{1}{64}$	0.006	0.008	0.010	......
Over 1 up to an including 2 in	$\frac{3}{64}$	$\frac{1}{32}$	0.008	0.012	0.015	$\frac{1}{32}$
Over 2 up to and including 4 in	$\frac{1}{16}$	$\frac{3}{64}$	0.010	0.015	0.020	$\frac{1}{32}$
Over 4 up to and including 6 in	$\frac{3}{32}$	$\frac{1}{16}$	0.010	0.015	0.020	$\frac{1}{32}$

Rejection. 14. (*a*) Unless otherwise specified any rejection based on tests made in accordance with Section 4 shall be reported within five working days from receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 15. Samples tested in accordance with Section 4, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

STEEL PLATES OF FLANGE AND FIREBOX QUALITIES FOR FORGE WELDING[1]

A.S.T.M. Designation: A 89 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover two grades of steel plate of flange and firebox qualities suitable for forge welding without the use of fluxes where the weld is not reinforced.

MANUFACTURE

Process. 2. The steel shall be made by either or both the following processes: open-hearth or electric-furnace.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 3. (*a*) The steel shall conform to the following requirements as to chemical composition:

		Flange		Firebox	
		Grade A	Grade B	Grade A	Grade B
Carbon, maximum, per cent...	for plates ¾ in. or under in thickness..	0.15	0.20	0.15	0.20
	for plates over ¾ in. in thickness.........	0.17	0.22	0.17	0.22
Manganese, per cent............		0.35–0.60	0.35–0.60	0.35–0.60	0.35–0.60
Phosphorus, maximum, per cent.	Acid......	0.06	0.06	0.04	0.04
	Basic.....	0.04	0.04	0.035	0.035
Sulfur, maximum, per cent..........		0.05	0.05	0.04	0.04

(*b*) The steel should preferably be free from nickel[2] and chromium. When these elements are present the maximum quantity of either one shall not exceed 0.05 per cent. Unless otherwise specified, the silicon shall not exceed 0.05 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A 89 - 30), see 1930 Book of A.S.T.M. Standards, Part I, p. 127. These specifications are identical with the Standard Specifications except for the addition of requirements for firebox quality material, the inclusion of requirements for elongation in 2 in. for material over 1½ in., and the elimination of the requirement that the steel should preferably be free from nickel in the case of material for fusion welding.

[2] **When these specifications are used for material to be fusion welded the maximum limit for nickel shall not apply.**

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus, and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	FLANGE		FIREBOX	
	GRADE A	GRADE B	GRADE A	GRADE B
Tensile strength, lb. per sq. in..	45 000	50 000	45 000[a]	50 000[a]
Yield point, lb. per sq. in.....	0.5 tens. str.	0.5 tens. str.	0.5 tens. str.	0.5 tens.str.
but in no case less than....	24 000	27 000	24 000	27 000
Elongation in 8 in.,[b] per cent..	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,500\,000}{\text{tens. str.}}$	$\frac{1\,550\,000}{\text{tens. str.}}$	$\frac{1\,550\,000}{\text{tens. str.}}$
Elongation in 2 in., per cent..	$\frac{1\,600\,000}{\text{tens. str.}}$	$\frac{1\,600\,000}{\text{tens. str.}}$	$\frac{1\,650\,000}{\text{tens. str.}}$	$\frac{1\,650\,000}{\text{tens. str.}}$

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[a] See Paragraph (*b*).

[b] See Section 7.

(*b*) Tensile strength only need be determined on the test specimen taken longitudinally from the top of firebox plates, and it shall not exceed 60,000 lb. per sq. in. for Grade A and 65,000 lb. per sq. in. for Grade B.

(*c*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine.

Modifications in Elongation. 7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentages of elongation in 8 in. specified in Section 6 (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in.

(*b*) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

Bend Tests. 8. The test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Homogeneity Tests.

9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. in length, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $\frac{1}{4}$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

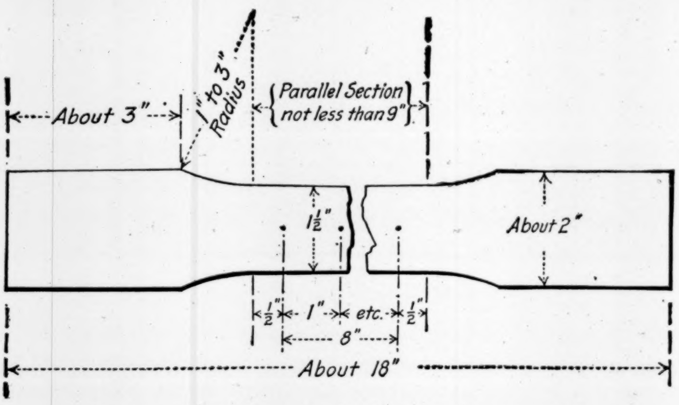


FIG. 1.—Standard 8-in. Gage Length Test Specimen.

Test Specimens.

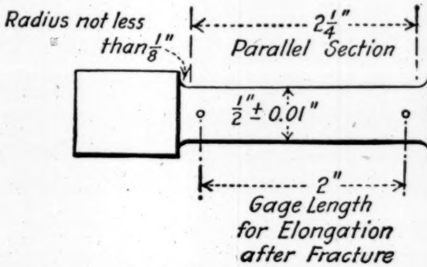
10. (*a*) Tension test specimens for firebox material shall be taken from the top and bottom corners of the plate as rolled, parallel to its longitudinal axis and for flange material from the bottom of the plate only. Bend test specimens shall be taken from the middle of the top of the plate as rolled, at right angles to its longitudinal axis.

(*b*) Tension and bend test specimens shall be of the full thickness of material as rolled, except as specified in Paragraphs (*c*) and (*d*), and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

(*c*) Tension test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in., or they may conform to the dimensions shown in Fig. 2.

(*d*) Bend test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. or to 1 by $\frac{1}{2}$ in. in section.

(*e*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 2.—Standard 2-in. Gage Length Test Specimen.

Number of Tests. 11. (*a*) Two tension and one bend test shall be made from each firebox steel plate as rolled. One tension and one bend test shall be made from each flange steel plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations. 12. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

FINISH

Finish. 13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking. 14. (*a*) The name or brand of the manufacturer, the manufacturer's test identification number, class, and lowest tensile strength for the grade specified in Section 6 (*a*) shall be legibly stamped on each plate. The manufacturer's test identification number shall be legibly stamped on each test specimen.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under $\frac{1}{8}$............	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl......	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over...........	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

NOTE.—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third the amount given in this table.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When the plate rolled from a slab or ingot is cut into two or more smaller plates, each shall be match-marked so that they may all be identified with the test specimens representing them.

(*c*) Each match-mark shall consist of two over-lapping circles, each not less than 1½ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

INSPECTION AND REJECTION

Inspection. 15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS

FOR

HEAT-TREATED CARBON-STEEL HELICAL SPRINGS[1]

A.S.T.M. Designation: A 125 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1929; REVISED, 1931.

Scope. 1. These specifications cover hot-coiled, helical compression springs made of round bars $\frac{1}{2}$ in. and larger in diameter and suitable for use on railway equipment.

MANUFACTURE

Process. 2. The steel may be made by one or more of the following processes: open-hearth, crucible or electric-furnace. The rolled bars shall be practically straight, free from surface cracks, rolling seams, folds and flat areas, or other injurious defects.

Coiling. 3. The bars after being suitably tapered or otherwise prepared shall be heated slowly and uniformly to a temperature of approximately 1700° F. (930° C.) and coiled on a preheated mandrel. No water shall be allowed to come in contact with the heated bar at any time.

Heat Treatment. 4. After coiling, the springs shall be allowed to cool uniformly to a distinct black heat. They shall then be reheated uniformly to a temperature sufficient to refine the grain and quenched in an ample volume of oil. After quenching the springs shall be allowed to cool to at least 400° F. (200° C.) and shall then be reheated uniformly to a temperature below the critical, but sufficiently high to give a proper drawback or tempering effect.

SAMPLING

Sampling. 5. The springs offered for inspection shall be arranged in groups with 500 or fraction thereof of a size in a group. The inspector shall select one spring from each group to represent that group and shall suitably mark the sample so selected for identification.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

6. (*a*) Unless otherwise specified, the steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.90 to 1.05
Manganese, per cent	0.25 to 0.50
Phosphorus, maximum, per cent	0.05
Sulfur, maximum, per cent	0.05
Silicon, minimum, per cent	0.15

(*b*) Other grades of steel may be used when mutually agreed upon by the purchaser and the manufacturer.

Check Analysis.

7. One check analysis may be made by the purchaser from each 500 springs or fraction thereof of each size of bar.

Preparation of Sample.

8. For chemical analysis, a spring if small shall be taken or if large a piece weighing about ½ lb. shall be cut off. If the sample is cut off hot it shall be cooled in such a way as not to permit it to harden. Drillings for check analysis shall be made from the samples so selected and the drill used shall be approximately one-half the diameter of the bar. The drillings for analysis shall be selected from the thoroughly-mixed total drillings obtained by passing nearly through the section of the bar after discarding the surface drillings.

PHYSICAL PROPERTIES AND TESTS

Number of Tests.

9. From each group of springs described in Section 5 which conform to the requirements of Sections 15 and 16 (*a*) the inspector may select 10 per cent to be tested in accordance with the requirements of Sections 10 and 11.

Physical Properties and Tests

10. (*a*) The properties specified in Paragraphs (*b*) to (*f*) shall be determined in the order enumerated. The springs shall not be rapped or otherwise disturbed during the test.

(*b*) *Solid Height.*—The solid height is the perpendicular distance between the plates of the testing machine when the spring is compressed solid with a test load of approximately one and one-quarter times that necessary to bring all coils in contact.

(*c*) *Free Height.*—The free height is the height of the spring when the load specified in Paragraph (*b*) has been released and is determined by placing a straight-edge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the straight-edge at the approximate center of the spring.

(*d*) *Loaded Height.*—The loaded height is the perpendicular distance between the plates of the testing machine when the specified working load has been applied.

TABLE I.—TEST LOADS IN POUNDS AND DEFLECTION PER TURN IN INCHES FOR HELICAL

Outside Diameter of Spring, in.		Diameter of Bar, in.									
		½	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1 1/16
2	Load	3272	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	0.134	.....	.....	.....	.....	.....	.....	.....	.....	.....
2¼	Load	2805	4140	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	0.183	0.152	.....	.....	.....	.....	.....	.....	.....	.....
2½	Load	2454	3606	5113	.....	.....	.....	.....	.....	.....	.....
	Deflection	0.239	0.200	0.168	.....	.....	.....	.....	.....	.....	.....
2¾	Load	2181	3194	4511	6187	.....	.....	.....	.....	.....	.....
	Deflection	0.303	0.254	0.216	0.185	.....	.....	.....	.....	.....	.....
3	Load	1963	2866	4036	5518	7363	.....	.....	.....	.....	.....
	Deflection	0.374	0.316	0.270	0.233	0.202	.....	.....	.....	.....	.....
3¼	Load	1785	2600	3652	4980	6627	8641	.....	.....	.....	.....
	Deflection	0.452	0.384	0.330	0.285	0.249	0.219	.....	.....	.....	.....
3½	Load	1636	2379	3334	4537	6025	7837	10022	.....	.....	.....
	Deflection	0.538	0.459	0.396	0.344	0.302	0.266	0.235	.....	.....	.....
3¾	Load	1510	2192	3065	4166	5522	7171	9150	11503	.....	.....
	Deflection	0.632	0.540	0.467	0.408	0.359	0.317	0.282	0.252	.....	.....
4	Load	1402	2033	2840	3852	5097	6608	8418	10564	13090	.....
	Deflection	0.733	0.628	0.545	0.477	0.421	0.374	0.334	0.299	0.269	.....
4¼	Load	.....	1895	2644	3581	4733	6127	7795	9767	12083	14777
	Deflection	.....	0.723	0.629	0.553	0.489	0.435	0.389	0.350	0.316	0.286
4½	Load	.....	1774	2474	3347	4418	5712	7257	9081	11220	13702
	Deflection	.....	0.824	0.718	0.632	0.561	0.500	0.449	0.405	0.366	0.333
4¾	Load	.....	.....	2324	3141	4142	5352	6789	8486	10472	12773
	Deflection	.....	.....	0.815	0.718	0.638	0.571	0.513	0.464	0.420	0.383
5	Load	.....	.....	2191	2959	3898	5030	6377	7964	9817	11962
	Deflection	.....	.....	0.916	0.810	0.720	0.646	0.582	0.527	0.479	0.436
5¼	Load	.....	.....	.....	2797	3681	4746	6013	7502	9240	11248
	Deflection	.....	.....	.....	0.906	0.808	0.725	0.654	0.594	0.540	0.494
5½	Load	.....	.....	.....	2651	3488	4493	5688	7091	8726	10614
	Deflection	.....	.....	.....	1.008	0.900	0.809	0.731	0.664	0.606	0.554
5¾	Load	.....	.....	.....	.....	3313	4266	5396	6723	8267	10049
	Deflection	.....	.....	.....	.....	0.997	0.898	0.812	0.739	0.675	0.618
6	Load	.....	.....	.....	.....	3155	4060	5133	6391	7854	9540
	Deflection	.....	.....	.....	.....	1.099	0.991	0.898	0.818	0.748	0.686
6¼	Load	.....	.....	.....	.....	.....	3874	4894	6090	7480	9080
	Deflection	.....	.....	.....	.....	.....	1.088	0.987	0.901	0.824	0.758
6½	Load	.....	.....	.....	.....	.....	3703	4676	5816	7140	8660
	Deflection	.....	.....	.....	.....	.....	1.191	1.081	0.987	0.905	0.833
6¾	Load	.....	.....	.....	.....	.....	.....	4478	5566	6829	8282
	Deflection	.....	.....	.....	.....	.....	.....	1.180	1.078	0.989	0.910
7	Load	.....	.....	.....	.....	.....	.....	4295	5337	6545	7933
	Deflection	.....	.....	.....	.....	.....	.....	1.283	1.172	1.077	0.993
7¼	Load	.....	.....	.....	.....	.....	.....	.....	5125	6283	7612
	Deflection	.....	.....	.....	.....	.....	.....	.....	1.271	1.168	1.078
7½	Load	.....	.....	.....	.....	.....	.....	.....	4930	6041	7317
	Deflection	.....	.....	.....	.....	.....	.....	.....	1.374	1.263	1.167
7¾	Load	.....	.....	.....	.....	.....	.....	.....	.....	5817	7043
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	1.363	1.259
8	Load	.....	.....	.....	.....	.....	.....	.....	.....	5610	6789
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	1.466	1.355
8¼	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8½	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8¾	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9¼	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9½	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9¾	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10½	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11½	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	Load	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Deflection	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

SPRINGS, CORRESPONDING TO A MAXIMUM FIBER STRESS OF 100,000 LB. PER SQ. IN.

Diameter of Bar, in.											Outside Diameter of Spring, in.
$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{9}{16}$	$1\frac{5}{8}$	$1\frac{11}{16}$		
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	2
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$2\frac{1}{4}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$2\frac{1}{2}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$2\frac{3}{4}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	3
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$3\frac{1}{4}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$3\frac{1}{2}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$3\frac{3}{4}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	4
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$4\frac{1}{4}$
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
16567	.....	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$4\frac{1}{2}$
0.302	.....	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
15424	18460	.....	.....	.....	.....	.....	.....	.....	.....	............Load	$4\frac{3}{4}$
0.349	0.319	.....	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
14429	17250	20450	.....	.....	.....	.....	.....	.....	.....	............Load	5
0.399	0.366	0.336	.....	.....	.....	.....	.....	.....	.....	.........Deflection	
13554	16185	19175	22545	.....	.....	.....	.....	.....	.....	............Load	$5\frac{1}{4}$
0.452	0.416	0.383	0.353	.....	.....	.....	.....	.....	.....	.........Deflection	
12780	15250	18045	21200	24750	.....	.....	.....	.....	.....	............Load	$5\frac{1}{2}$
0.509	0.468	0.432	0.400	0.370	.....	.....	.....	.....	.....	.........Deflection	
12089	14415	17040	20005	23335	27045	.....	.....	.....	.....	............Load	$5\frac{3}{4}$
0.569	0.524	0.484	0.449	0.416	0.387	.....	.....	.....	.....	.........Deflection	
11469	13665	16145	18940	22070	25565	29450	.....	.....	.....	............Load	6
0.632	0.583	0.540	0.501	0.465	0.433	0.404	.....	.....	.....	.........Deflection	
10910	12990	15340	17980	20940	24235	27900	31955	.....	.....	............Load	$6\frac{1}{4}$
0.699	0.645	0.598	0.556	0.517	0.482	0.450	0.420	.....	.....	.........Deflection	
10402	12379	14610	17115	19920	23040	26505	30340	34565	.....	............Load	$6\frac{1}{2}$
0.768	0.711	0.659	0.613	0.571	0.533	0.498	0.467	0.437	.....	.........Deflection	
9940	11823	13945	16325	18995	21955	25245	28875	32880	37275	............Load	$6\frac{3}{4}$
0.841	0.779	0.724	0.674	0 628	0.587	0.550	0.515	0.483	0.454	.........Deflection	
9517	11314	13340	15610	18150	20970	24095	27550	31350	35520	............Load	7
0.918	0.851	0.791	0.737	0.688	0.644	0.603	0.566	0.532	0.500	.........Deflection	
9129	10847	12780	14950	17375	20065	23050	26340	29955	33920	............Load	$7\frac{1}{4}$
0.998	0.926	0.861	0.804	0.751	0.703	0.659	0.619	0.582	0.548	.........Deflection	
8770	10418	12270	14345	16665	19240	22090	25230	28680	32460	............Load	$7\frac{1}{2}$
1.081	1.004	0.935	0.873	0.816	0.765	0.718	0.675	0.635	0.599	.........Deflection	
8440	10020	11800	13790	16015	18480	21205	24210	27510	31125	............Load	$7\frac{3}{4}$
1.167	1.085	1.011	0.945	0.884	0.829	0.779	0.733	0.691	0.651	.........Deflection	
8133	9653	11360	13275	15405	17770	20390	23270	26430	29890	............Load	8
1.256	1.169	1.090	1.020	0.955	0.896	0.842	0.793	0.748	0.706	.........Deflection	
7847	9312	10955	12795	14845	17120	19635	22400	25435	28755	............Load	$8\frac{1}{4}$
1.350	1.256	1.173	1.097	1.028	0.965	0.908	0.856	0.808	0.763	.........Deflection	
7581	8993	10575	12350	14825	16515	18935	21590	24510	27700	............Load	$8\frac{1}{2}$
1.447	1.347	1.258	1.177	1.104	1.038	0.977	0.921	0.870	0.823	.........Deflection	
.....	8696	10225	11935	13840	15950	18280	20840	23650	26710	............Load	$8\frac{3}{4}$
.....	1.441	1.346	1.260	1.183	1.113	1.048	0.989	0.934	0.884	.........Deflection	
.....	8418	9895	11550	13385	15420	17670	20140	22845	25805	............Load	9
.....	1.538	1.437	1.347	1.265	1.190	1.122	1.059	1.001	0.948	.........Deflection	
.....	.....	9585	11185	12960	14930	17100	19485	22100	24950	............Load	$9\frac{1}{4}$
.....	.....	1.532	1.436	1.349	1.270	1.198	1.131	1.070	1.014	.........Deflection	
.....	.....	9295	10840	12565	14465	16565	18870	21395	24150	............Load	$9\frac{1}{2}$
.....	.....	1.629	1.528	1.436	1.353	1.276	1.206	1.141	1.082	.........Deflection	
.....	.....	.....	10520	12190	14030	16065	18295	20740	23405	............Load	$9\frac{3}{4}$
.....	.....	.....	1.622	1.526	1.438	1.357	1.283	1.215	1.152	.........Deflection	
.....	.....	.....	10220	11835	18620	15590	17755	20120	22700	............Load	10
.....	.....	.....	1.720	1.619	1.526	1.441	1.363	1.291	1.225	.........Deflection	
.....	.....	.....	.....	11185	12870	14725	16760	18985	21410	............Load	$10\frac{1}{2}$
.....	.....	.....	.....	1.811	1.709	1.615	1.530	1.450	1.377	.........Deflection	
.....	.....	.....	.....	.....	12200	13950	15870	17975	20260	............Load	11
.....	.....	.....	.....	.....	1.903	1.800	1.705	1.618	1.537	.........Deflection	
.....	.....	.....	.....	.....	.....	13250	15075	17065	19230	............Load	$11\frac{1}{2}$
.....	.....	.....	.....	.....	.....	1.994	1.891	1.795	1.707	.........Deflection	
.....	.....	.....	.....	.....	.....	.....	14350	16240	18295	............Load	12
.....	.....	.....	.....	.....	.....	.....	2.086	1.981	1.885	.........Deflection	

(*e*) *Uniformity of Pitch.*—The pitch of the coils shall be sufficiently uniform that when the springs are compressed to a point where any two coils are in contact there shall be no space exceeding $\frac{1}{32}$ in. between the other coils, excluding the tapered ends.

(*f*) *Permanent Set.*—The permanent set is the difference, if any, between the free height and the height after the spring has been compressed solid three times with the test load specified in Paragraph (*b*), measured at the same point and in the same manner.

Tolerances. 11. (*a*) Springs having a free height of 10 in. and under shall conform to the following tolerances when tested in accordance with Section 10:

Diameter.—The diameter of the springs up to 6 in. in outside diameter shall not vary more than $\frac{1}{16}$ in. from that specified and for springs over 6 in. in outside diameter the diameter shall not vary more than $\frac{1}{8}$ in. from that specified.

Solid Height.—Not more than $\frac{1}{16}$ in. over that specified.

Free Height.—Not more than $\frac{1}{8}$ in. over or under that specified.

Loaded Height.—Not more than $\frac{1}{8}$ in. over nor more than $\frac{1}{16}$ in. under that specified.

Uniformity of Pitch.—As specified in Section 10 (*e*).

Permanent Set.—Not more than $\frac{1}{32}$ in.

Increased Tolerances. (*b*) For springs having a free height over 10 in. but not over 15 in. the tolerances specified in Paragraph (*a*) shall be increased 50 per cent.

(*c*) For springs having a free height over 15 in. but not over 20 in. the tolerances specified in Paragraph (*a*) shall be increased 100 per cent.

(*d*) For springs having a free height over 20 in. the tolerances shall be mutually agreed upon by the manufacturer and the purchaser.

Testing Stress. 12. (*a*) The properties and methods of testing specified in Sections 10 and 11 have been established on the assumption that the maximum fiber stress at the solid height shall not exceed 100,000 lb. per sq. in. and that the several heights specified are commensurate. The stress of 100,000 lb. per sq. in. referred to is given solely as a limiting stress not to be exceeded in testing. This stress is not intended as a guide in the design of springs, as the proper working fiber stress will depend upon the class of the spring and upon the service for which it is intended.

(*b*) Unless otherwise mutually agreed upon by the manufacturer and purchaser, springs which do not meet the conditions of Paragraph (*a*) shall not be subject to the requirements of Sections 10 and 11, but shall be submitted to a test load which corresponds to a maximum fiber stress of 100,000 lb. per sq. in. as determined in Section 13. The free height as measured after application and release of such test load shall conform to the requirements of Section 11.

Test Loads. 13. The test load corresponding to a maximum fiber stress of 100,000 lb. per sq. in. shall be calculated from the following equation:

$$C = \frac{3.1416\, S\, d^3}{8\, M} \qquad (1)$$

where C = the capacity in pounds;

S = the stress at the most strained fiber = 100,000 lb. per sq. in.;

d = the diameter of the bar in inches;

M = the mean diameter of the helix in inches, found by subtracting the diameter of the bar from the outside diameter of the spring.

Table I shows test loads in pounds and deflection per turn in inches for helical springs, corresponding to a maximum fiber stress of 100,000 lb. per sq. in. for springs 2 to 12 in. in outside diameter.

Calculation. 14. To determine whether or not the specified heights fulfill the conditions of Section 12 (*a*) the calculations described in Paragraphs (*a*) to (*f*), inclusive, shall be made.

(*a*) Divide the solid height by the diameter of the bar to obtain the number of turns in the spring. From the figure thus obtained subtract one and one-half to obtain the number of acting turns.

NOTE.—There is one turn of inactive material at each end of a spring, counting from the tip of the tapered bar. In measurements parallel to the axis of the spring, this is equal to one and one-half times the diameter of the bar, being made up of the two tips of the bar, each one-quarter of the bar diameter in thickness and one full bar diameter.

(*b*) The deflection corresponding to the load determined by the equation in Section 13 shall be calculated from the following equation:

$$F = \frac{3.1416\, S\, M^2\, N}{G\, d} \qquad (2)$$

where S, M, and d are the same as in Eq. 1;

F = the deflection;

N = the number of active turns; and

G = the effective torsional modulus of elasticity. For the grade of steel herein specified G shall be taken at 10,500,000 lb. per sq. in.

Table I shows test loads in pounds and deflection per turn in inches for helical springs, corresponding to a maximum fiber stress of 100,000 lb. per sq. in. for springs 2 to 12 in. in outside diameter.

(*c*) The sum of the solid height and the total deflection F is the "normal free height" and should not be exceeded by the free height.

(*d*) In helical springs the loads and deflections are directly proportional. Therefore, the deflection, X, under any load, P, less than the capacity shall be determined from the ratio: $C:F::P:X$ by solving for X.

(*e*) The sum of the specified loaded height and X is the required free height which shall not exceed the normal free height.

(*f*) Should the specified free height exceed the normal free height or be less than the required free height or both, the several specified heights are not commensurate.

WORKMANSHIP AND FINISH

Workmanship. 15. Before offering springs for inspection they shall be compressed solid three times. The springs shall be submitted for inspection singly or grouped as may be shown by the drawings and shall conform to the drawings within the tolerances specified in Section 11.

Finish. 16. (*a*) The ends of the bars shall be properly tapered to give when coiled a reasonable square, firm bearing. The points of the bars shall be in approximate contact with the adjacent coil and shall not protrude beyond the outside diameter of the springs.

(*b*) When mutually agreed upon by the manufacturer and purchaser, the end bearing surfaces of the springs shall be ground to produce a uniform bearing of at least three-fourths of the circumference and square with the axis of the helix within $\frac{1}{8}$ in. per foot of free length.

MARKING

Marking. 17. (*a*) The name or brand of the manufacturer, the year and month of manufacture and, if specified, the purchaser's class number shall be legibly stamped on each spring at a place not detrimental to the life of the spring.

(*b*) Any stamping by the inspector shall be so placed as not to be detrimental to the life or service of the spring.

INSPECTION AND REJECTION

Inspection. 18. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the springs ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the springs are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

19. (*a*) If any of the springs representing a group fail to conform to the requirements specified in Section 11, but at least one-half of the springs representing a group do conform to these requirements, each spring of the group shall be tested, and those which conform to the requirements shall be accepted. If more than one-half of the springs representing a group fail to conform to requirements specified in Section 11, the group shall be rejected.

(*b*) Individual springs which, subsequent to inspection at the mills or elsewhere and their acceptance, show defects or imperfections will be rejected and shall be replaced by the manufacturer.

Rehearing.

20. Samples tested in accordance with Section 6, which represent rejected material, shall be held for two weeks from the date of the test report.

Reworking.

21. Springs which fail to conform to the requirements of the physical tests or conform to the specified dimensions may be again submitted after being reworked.

TENTATIVE SPECIFICATIONS
FOR
CARBON-STEEL FORGINGS FOR LOCOMOTIVES[1]

A.S.T.M. Designation: A 20 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ADOPTED, 1912; REVISED, 1913, 1914, 1916, 1921, 1925, 1927, 1928; REISSUED IN TENTATIVE FORM, 1929; REVISED, 1931.

Scope. 1. These specifications cover untreated, annealed, and normalized and tempered carbon-steel driving axles, engine and trailing-truck axles, main and side rods, straps, crank pins, piston rods, and annealed car and tender axles.

Basis of Purchase. 2. The manufacturer may, at his option, furnish annealed forgings when untreated forgings are specified by the purchaser, provided they conform to the requirements specified for untreated forgings.

MANUFACTURE

Process. 3. The steel shall be made by either or both the following processes: open hearth or electric-furnace.

Discard. 4. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Prolongations for Tests. 5. Unless otherwise specified, for test purposes at least 20 per cent of the forgings shall be provided with prolongations or, at the manufacturer's option, a forging may be selected.

Boring. 6. If boring is required in the case of axles, shafts and similar forgings, it shall be performed before heat treatment and the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

Heat Treatment. 7. (*a*) *Cooling.*—After forging, the objects shall be allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

These tentative specifications are in effect a revision of the former Standard Specifications for Carbon-Steel Forgings for Locomotives (A.S.T.M. Designation: A 20 - 28) which were discontinued in 1929.

(*b*) *Annealing.*—For annealing, the forgings shall be uniformly reheated to the proper temperature to refine the grain and allowed to cool uniformly. A group thus treated shall be known as an "annealing charge."

(*c*) *Normalizing.*—For normalizing, the forgings shall be uniformly reheated to a proper temperature to refine the grain, and after being held a sufficient length of time at this temperature, shall be withdrawn from the furnace and allowed to cool uniformly in the atmosphere, protected from rain or snow, to a temperature below the critical range. A group of forgings thus heated shall be known as a "normalizing charge." Normalizing, when specified, shall be followed either by annealing as described in Paragraph (*b*), or by tempering as described in Paragraph (*d*).

(*d*) *Tempering.*—For tempering, after normalizing as described in Paragraph (*c*), the forging shall be uniformly reheated to a temperature below the critical range, and after being held a proper time at this temperature shall be allowed to cool uniformly either in the furnace or in the atmosphere protected from rain or snow. A group of forgings thus treated shall be known as a "tempering charge."

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

8. The steel shall conform to the following requirements as to chemical composition:

Manganese	For untreated forgings	0.50 to 0.80 per cent
	For heat-treated forgings	0.60 to 0.90 per cent
Phosphorus		not over 0.05 per cent
Sulfur		not over 0.05 per cent

Ladle Analyses.

9. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon and the elements specified in Section 8. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and the percentages of manganese, phosphorus and sulfur shall conform to the requirements specified in Section 8.

Check Analyses.

10. An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 8. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface; or turnings may be taken from a test specimen.

PHYSICAL PROPERTIES AND TESTS

Tension Tests. 11. (*a*) The forgings shall conform to the minimum requirements as to tensile properties specified in Table I.

(*b*) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(*c*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the testing machine, by which is meant the speed of the cross-head when the machine is running idle, shall not be less than $\frac{1}{16}$ nor more than $\frac{1}{8}$ in. per minute.

TABLE I.—MINIMUM TENSILE REQUIREMENTS FOR FORGINGS HAVING A MAXIMUM OUTSIDE DIAMETER OR OVER-ALL THICKNESS OF NOT OVER 12 IN. WHEN UNTREATED OR NOT OVER 20 IN. WHEN TREATED.

Size, Outside Diameter or Over-all Thickness	Tensile Strength, lb. per sq. in.	Yield Point, lb. per sq. in.	Elongation in 2 in., per cent		Reduction of Area per cent	
			Inverse Ratio	Not Under	Inverse Ratio	Not Under
UNTREATED						
Not over 8 in.	75 000	0.5 tens. str.	$\frac{1\,600\,000}{\text{Tens. str.}}$	18	$\frac{2\,200\,000}{\text{Tens. str.}}$	24
Over 8 to 12 in., inclusive	75 000	0.5 tens. str.	$\frac{1\,500\,000}{\text{Tens. str.}}$	17	$\frac{2\,000\,000}{\text{Tens. str.}}$	23
ANNEALED						
Not over 8 in., 4-in. maximum wall	80 000	0.48 tens. str.	$\frac{1\,980\,000}{\text{Tens. str.}}$	22	$\frac{3\,100\,000}{\text{Tens. str.}}$	35
Over 8 to 12 in., 6-in. maximum wall	80 000	0.48 tens str.	$\frac{1\,900\,000}{\text{Tens. str.}}$	21	$\frac{2\,900\,000}{\text{Tens. str.}}$	33
Over 12 to 20 in., 10-in. maximum wall	80 000	0.48 tens. str.	$\frac{1\,820\,000}{\text{Tens. str.}}$	20	$\frac{2\,640\,000}{\text{Tens. str.}}$	31
NORMALIZED AND TEMPERED						
Not over 8 in., 4-in. maximum wall	85 000	0.52 tens. str.	$\frac{2\,300\,000}{\text{Tens. str.}}$	25	$\frac{3\,650\,000}{\text{Tens. str.}}$	40
Over 8 to 12 in., 6-in. maximum wall	83 000	0.52 tens. str.	$\frac{2\,100\,000}{\text{Tens. str.}}$	23	$\frac{3\,320\,000}{\text{Tens. str.}}$	37
Over 12 to 20 in., 10-in. maximum wall	83 000	0.52 tens. str.	$\frac{2\,000\,000}{\text{Tens. str.}}$	22	$\frac{3\,100\,000}{\text{Tens. str.}}$	35

(*d*) Tests of forgings shall be made only after final heat-treatment.

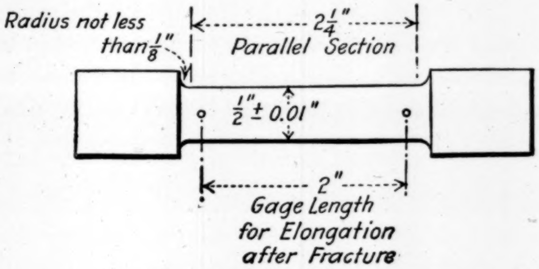
Bend Tests. 12. If specified by the purchaser, bend tests shall be made on annealed, and normalized and tempered forgings as follows: The test specimen shall stand being bent cold through 180 deg. around a pin $\frac{1}{2}$ in. in diameter without cracking on the outside of the bent portion.

Test Specimens. 13. (*a*) Tension and bend test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross-section as that of the forging back of the large end or collar. If approved by the purchaser, the specimens may be taken from the forging itself with a hollow drill.

(*b*) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer wall surfaces of bored forgings and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(*c*) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*d*) Bend test specimens shall be $\frac{1}{2}$-in. square in section with corners rounded to a radius of not over $\frac{1}{16}$ in. and the length need not exceed 6 in.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Test Specimen.

Number of Tests.

14. Unless otherwise specified by the purchaser, tests shall be made as follows:

(*a*) For untreated forgings, one tension test shall be made from each melt.

(*b*) For annealed forgings, one tension test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension test shall be made from each melt.

(*c*) For normalized and tempered forgings, one tension test, and when specified one bend test, shall be made from each tempering charge. If more than one normalizing charge is represented in a tempering charge, one tension test, and when specified one bend test, shall be made from each normalizing charge. If more than one melt is represented in a normalizing charge, one tension test, and when specified one bend test, shall be made from each melt.

(*d*) If more than one class of forgings by size is represented in any lot, one tension test, and when specified one bend test, from a forging of each class by size shall be made in accordance with Sections 11, 12 and 13.

(*e*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*f*) If the percentage of elongation of any test specimen is less than that specified in Section 11 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests. 15. (*a*) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-treat such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 14.

(*b*) When annealed, or normalized and tempered forgings are specified, if the fracture of any test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be re-treated. The fracture shall be considered crystalline if the crystals which it contains are so large that the cleavage planes or sides of these crystals are easily visible to the naked eye.

WORKMANSHIP AND FINISH

Workmanship. 16. The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough-turned all over with an allowance of ⅛ in. on the surface for finishing. In centering, 60-deg. centers with clearance drilled for points shall be used.

Finish. 17. The forgings shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking. 18. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

INSPECTION AND REJECTION

Inspection. 19. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

20. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 19(*b*) shall be reported within five working days from the receipt of samples.

(*b*) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rehearing.

21. Samples tested in accordance with Section 19(*b*), which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
NORMALIZED AND TEMPERED ALLOY-STEEL FORGINGS FOR LOCOMOTIVES[1]

A.S.T.M. Designation: A 133 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1931.

Scope. 1. (*a*) These specifications cover two classes of normalized and tempered alloy-steel forgings for use in locomotive construction.

(*b*) The characteristics of the two classes are as follows:

Class A.—Medium tensile strength with high yield point and high ductility.

Class. B.—High tensile strength with considerable ductility.

MANUFACTURE

Process. 2. The steel shall be made by either or both the following processes: open-hearth or electric-furnace.

Discard. 3. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Prolongations for Tests. 4. Unless otherwise specified, for purposes of test, at least 20 per cent of the forgings shall be provided with prolongations, or at the manufacturer's option, a forging may be selected.

Boring. 5. If boring is required in the case of axles, shafts and similar forgings, it shall be performed before heat treatment, and the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

Heat Treatment. 6. (*a*) *Cooling.*—After forging, the objects shall be allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling.

(*b*) *Normalizing.*—For normalizing, the forgings shall be uniformly reheated to a proper temperature to refine the grain, and after being held a sufficient length of time at this temperature, shall be withdrawn from the furnace and allowed to cool uniformly in still air, protected from rain or snow, to a temperature below the critical range. A group of forgings thus heated shall be known as a "normalizing charge."

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

(*c*) *Tempering.*—For tempering, after normalizing as described in Paragraph (*b*), the forgings shall be uniformly reheated to a temperature below the critical range, and after being held a proper time at this temperature shall be allowed to cool uniformly either in the furnace or in the atmosphere protected from rain or snow. A group of forgings thus treated shall be known as a "tempering charge."

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

7. (*a*) The steel shall conform to the following requirements as to chemical composition:

Phosphorus, maximum, per cent	0.045
Sulfur, maximum, per cent	0.050

(*b*) The composition other than phosphorus and sulfur shall be agreed upon by the manufacturer and the purchaser.

NOTE.—Compositions which have been used successfully to give the physical properties specified in Section 10 are as follows:

	CLASS A	CLASS B
Carbon, per cent	0.20 to 0.30	0.42 to 0.57
Manganese, per cent	0.80 to 1.00	0.70 to 0.95
Silicon, per cent	not less than 0.15	not less than 0.15
Nickel, per cent	2.50 to 3.00	not over 0.25
Chromium, per cent	not over 0.40	not over 0.40
Vanadium, per cent	not over 0.05	not less than 0.15

Ladle Analyses.

8. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon and the elements specified in Section 7. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 7.

Check Analyses.

9. An analysis may be made by the purchaser from a forging representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from the forging or from a full-size prolongation of the same, at any point midway between the center and surface; or turnings may be taken from a test specimen.

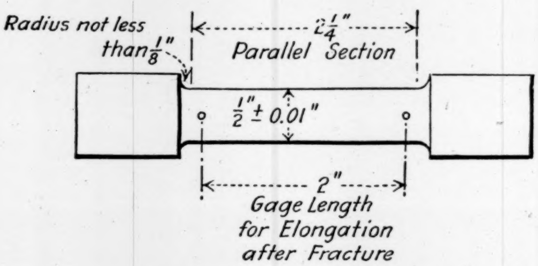
PHYSICAL PROPERTIES AND TESTS

Tension Tests. 10. (*a*) The forgings shall conform to the following minimum requirements as to tensile properties:

	Class A Not Over 14 in. in Diameter, or Thickness, 7-in. Maximum Wall	Class B Not Over 14 in. in Diameter, or Thickness, 7-in. Maximum Wall
Tensile Strength, lb. per sq. in.........	80 000	90 000
Yield Point, lb. per sq. in..............	0.67 ten. str.	0.62 ten. str.
Elongation in 2 in., per cent...........	28	22
Reduction of Area, per cent...........	56	42

(*b*) The yield point shall be determined by the drop of the beam or halt in the gage of the testing machine. The speed of the testing machine shall be such that when running light the crosshead speed shall not be less than $\frac{1}{16}$ in. nor more than $\frac{1}{8}$ in. per minute.

(*c*) Tests of forgings shall be made only after final treatment.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Test Specimen.

Bend Tests. 11. If specified by the purchaser, bend tests shall be made as follows:

The test specimen shall stand being bent cold through 180 deg. around a pin $\frac{1}{2}$ in. in diameter without cracking on the outside of bent portion.

Test Specimens. 12. (*a*) Tension and bend test specimens shall be taken from a full-size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross-section as that of the forging back of the large end or collar. The specimens may be taken from the forging itself with a hollow drill if approved by the purchaser.

(*b*) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer wall surfaces of bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(*c*) Tension test specimen shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*d*) Bend test specimens shall be $\frac{1}{2}$ in. square in section with corners rounded to a radius not over $\frac{1}{16}$ in., and need not exceed 6 in. in length.

Number of Tests.

13. (*a*) One tension test, and when specified one bend test, shall be made from each tempering charge. If more than one normalizing charge is represented in a tempering charge, one tension test, and when specified one bend test, shall be made from each normalizing charge. If more than one melt is represented in a normalizing charge one tension test, and when specified one bend test, shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests.

14. If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 13.

WORKMANSHIP AND FINISH

Workmanship.

15. The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts, and similar forgings, unless otherwise specified, shall be rough turned all over with an allowance of $\frac{1}{8}$ in. on the surface for finishing. In centering, 60-deg. centers with clearance drilled for points shall be used.

Finish.

16. The forgings shall be free from injurious defects and shall have a workmanlike finish.

MARKING

Marking.

17. Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

INSPECTION AND REJECTION

Inspection.

18. (*a*) The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which con-

cern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection. 19. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 18 (*b*) shall be reported within five working days from the receipt of samples.

(*b*) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Rehearing. 20. Samples tested in accordance with Section 18 (*b*) which represent rejected forgings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
ELECTRIC-FUSION-WELDED STEEL PIPE[1]

A.S.T.M. Designation: A 134 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. These specifications cover steel pipe, with a wall thickness up to $\frac{5}{8}$ in. inclusive, manufactured by the electric-fusion-welding process.

MATERIAL

Plates. 2. The steel plate shall conform to the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A.S.T.M. Designation: A 78) or the Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A.S.T.M. Designation: A 89) of the American Society for Testing Materials,[3] or equally suitable weldable material as specified.[4]

MANUFACTURE

Manufacture. 3. The longitudinal edges of the plate shall be machined to a shape that will give the most satisfactory results in electric-fusion welding. The plate shall then be properly formed and may be tacked preparatory to welding. The weld shall be made by automatic means and shall be of reasonably uniform width and height for the entire length of the pipe.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

[3] 1930 Book of A.S.T.M. Standards, Part I, pp. 122 to 130.

[4] It is the opinion of Committee A-1 on Steel that steel made in accordance with the following specifications of the American Society for Testing Materials can be welded satisfactorily by the usual fusion-welding processes now in general use:

Standard Specifications for Structural Steel for Bridges (A 7), Structural Steel for Buildings (A 9), Structural Steel for Locomotives and Cars (A 113), Boiler and Firebox Steel for Locomotives (A 30), Boiler and Firebox Steel for Stationary Service (A 70), Steel Plates of Structural Quality for Forge Welding (A 78), Steel Plates of Flange Quality for Forge Welding (A 89), and Tentative Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 31 T), Open-Hearth Iron Plates of Flange Quality (A 129 – 30 T), and Structural Steel for Ships (A 131 – 31 T).

In connection with carbon limitations in the above specifications, the committee was of the opinion that, while higher carbon steels are successfully welded, commercial practice at present often limits the carbon (by ladle test) to 0.30 per cent in open-hearth steel and 0.15 per cent in bessemer steel.

PHYSICAL PROPERTIES AND TESTS

Tension Test.

4. If required by the purchaser, the test specimen taken across the weld shall show a tensile strength not less than the minimum tensile strength specified for the plate.

Bend Test.

5. If required by the purchaser, the test specimen taken across the weld shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to $4\frac{1}{2}$ times the thickness of the plate, without developing cracks. In making the test, the specimen shall be placed with the side of the specimen representing the inside of the pipe, next the pin.

Hydrostatic Test.

6. (*a*) Unless otherwise specified, each length of pipe shall be tested at the mill to a hydrostatic pressure equal to 150 per cent of the working pressure but in no case shall the test stress exceed 36 per cent of the minimum tensile strength specified. The working pressure shall be calculated from the following formula:

$$P = \frac{2\,St}{D}$$

where P = the working pressure in pounds per square inch;
S = the allowable fiber stress in pounds per square inch;
t = the wall thickness in inches, and
D = the outside diameter in inches.

(*b*) While under test pressure the pipe shall be jarred with a 2-lb. hammer or its equivalent.

Test Specimens.

7. (*a*) If required by the purchaser, test specimens shall be taken across the weld and from the end of the pipe or from any point in the pipe required by the inspector and shall be cut perpendicularly to the axis of the pipe with the weld approximately in the middle of the specimen. The tension test specimen shall be flattened and machined on the sides. The bend test specimen shall have the protruding portions of the weld, from both inside and outside of the pipe, removed by machining or grinding.

(*b*) All specimens shall be tested at room temperature.

(*c*) The openings resulting from the removal of test specimens shall be patched in a manner approved by the purchaser.

Number of Tests.

8. (*a*) From each lot of 100 lengths or fraction thereof the purchaser may select at random one pipe for the tests specified in Sections 4 and 5.

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 6.

Retests.

9. (*a*) If the results of the tension or bend tests of any lot do not conform to the requirements specified in Sections 4 and 5, retests of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

(*b*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Permissible Variations.

10. (*a*) *Weight.*—Tolerances on theoretical weights of pipe shall be governed by weight tolerances for plates as covered in specifications of the American Society for Testing Materials to which the plates are ordered.

(*b*) *Diameter.*—The outside diameter of the pipe shall be within tolerances consistent with the method of field joints. When necessitated by the type of field joint employed for sizes 30 in. or smaller, the outside diameter of the pipe shall not be more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe, and shall permit the passing, for the distance of 8 in., of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter.

Lengths.

11. Standard lengths of pipe shall be approximately 30 to 40 ft. Not more than 2 per cent of the total number of lengths may be shorter than 30 ft., excepting in the case of specials, such as reducers, etc. On pipe of larger diameter one or more circumferential joints may be made by welding or riveting, as specified.

WORKMANSHIP AND FINISH

Workmanship and Finish.

12. The finished pipe shall be reasonably straight, sized at the ends as required, and free from injurious defects.

Repairing Defects.

13. The welding of injurious defects in the pipe wall, provided their depth does not exceed one-third the nominal wall thickness, shall be permitted. Defects in the welds such as sweats or leaks, unless otherwise specified, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity and then welding. All repaired pipe shall be retested hydrostatically.

PROTECTIVE COATING

Protective Coating.

14. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating specified by the purchaser.

INSPECTION AND REJECTION

Inspection

15. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern

the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
ELECTRIC-RESISTANCE-WELDED STEEL PIPE[1]

A.S.T.M. Designation: A 135 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope.

1. These specifications cover electric-resistance-welded steel pipe in two grades, soft and medium, intended for bending, flanging and other special purposes; and for the conveying of vapors or liquids. The suitability of pipe for various purposes is somewhat dependent upon size and composition, so that the purpose for which the pipe is intended should be stated in the order.

MANUFACTURE

Process.

2. Unless otherwise specified, the steel shall be made by the open-hearth process.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. Open-hearth steel shall conform to the following ladle analysis requirements as to chemical composition:

Phosphorus, maximum, per cent	0.045
Sulfur, maximum, per cent	0.060

Ladle Analyses.

4. An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. When requested by the purchaser, the chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 3.

Check Analyses.

5. (*a*) Analyses of two pipes in each lot of 400 lengths or fraction thereof of each size under 6 in. and in each lot of 200 lengths or fraction thereof of each size 6 to 20 in., and in each lot of 100 lengths or fraction

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

thereof in sizes over 20 in., may be made by the purchaser from the finished pipe. By agreement between the manufacturer and the purchaser, the analyses may be made on the plate and the number shall be determined in the same manner as when taken from the finished pipe. The chemical composition thus determined shall conform to the requirements specified in Section 3. Drillings for analysis shall be taken from several points around each pipe, or across each piece of skelp, selected for analysis.

(*b*) *Retests.*—If the analysis of either length of pipe or skelp does not conform to the requirements specified in Section 3, analyses of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

PHYSICAL PROPERTIES AND TESTS

Tension Tests.

6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	Soft Grade		Medium Grade	
	Skelp Tests	Pipe Tests	Skelp Tests	Pipe Tests
Tensile strength, lb. per sq. in.	48 000	48 000	58 000	60 000
Yield point, lb. per sq. in.	30 000	30 000	33 000	35 000
Elongation in 2 in., per cent	35	30	30	25
Elongation in 8 in., per cent	22	18	..	..

(*b*) If requested by the purchaser, the tensile strength across the weld shall not be less than the minimum tensile strength of the grade of steel ordered.

(*c*) The yield point shall be determined by the drop of the beam of the testing machine or other approved method.

Hydrostatic Tests.

7. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D}$$

where P = the hydrostatic test pressure in pounds per square inch;
S = the allowable fiber stress: 14,000 to 16,000 lb. per sq. in. for soft grade; 20,000 to 22,000 lb. per sq. in. for medium grade, but in no case shall the hydrostatic pressure exceed 2500 lb. per sq. in.;
t = the wall thickness in inches; and
D = the outside diameter in inches.

(*b*) While under test pressure the pipe shall be jarred with a 2-lb. hammer or its equivalent.

Flattening Tests.

8. Both crop ends from each length of pipe shall be flattened between parallel plates with the weld at the point of maximum bend-

ing until opposite walls of the pipe meet. No opening in the weld shall take place until the distance between the plates is less than two-thirds of the original outside diameter of the pipe. No cracks or breaks in the metal elsewhere than in the weld shall occur until the distance between the plates is less than one-third of the original outside diameter of the pipe, but in no case less than five times the thickness of the pipe wall. Evidence of lamination or burnt material shall not develop during the entire flattening process, and the weld, if fractured after crushing to less than two-thirds the original outside diameter of the pipe, shall not show injurious defects.

Test Specimens

9. (*a*) Longitudinal tension test specimens shall be taken from the end of the pipe from a point approximately 90 deg. from the weld, and shall not be flattened between gage marks. Transverse tension test specimens shall be taken across the weld and from the same end of the pipe as the longitudinal test specimen. The sides of the specimens shall be parallel between gage marks. If desired, the tension test specimen may consist of a full section of the pipe. When impracticable to pull a test specimen in full thickness the A.S.T.M. standard 2-in. gage length test specimen may be used. By agreement between the manufacturer and the purchaser, the longitudinal tension test specimen may be taken from the skelp.

(*b*) All specimens shall be tested at room temperature.

Number of Tests.

10. (*a*) One longitudinal and, if requested by the purchaser, one transverse tension test shall be made on a length in each lot of 400 lengths or fraction thereof of each size under 6 in., and in each lot of 200 lengths or fraction thereof of each size 6 to 20 in., and in each lot of 100 lengths or fraction thereof in sizes over 20 in. When taken from the skelp, the number of tests shall be determined in the same manner as when taken from the finished pipe.

(*b*) Each length of pipe shall be subjected to the hydrostatic test specified in Section 7.

(*c*) The flattening test specified in Section 8 shall be made on both crop ends cut from each length of pipe.

Retests.

11. (*a*) If the results of the tension test of any lot do not conform to the requirements specified in Section 6, retests of two additional pipes from the same lot for each failure shall be made, each of which shall conform to the requirements specified.

(*b*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, it may be discarded and another specimen substituted.

(*c*) If any section fails when flattening tests are made on the crop ends of each length of pipe, other pieces from the length may be cut until satisfactory tests are obtained, otherwise the length shall be rejected. Precautions shall be taken so that crop ends may be identified with respect to the length from which they were cut.

(*d*) If any specimen shows defective machining or develops flaws not associated with the welding it may be discarded and another specimen substituted.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Permissible Variations.

12. (*a*) *Weight.*—The weight of the pipe shall not vary more than ±5 per cent from the weight ordered. The weight of a carload lot shall not be more than $2\frac{1}{2}$ per cent under the weight ordered.

(*b*) *Diameter.*—For pipe 2 in. or over, but under 16 in., in diameter, the outside diameter shall not vary more than 1 per cent over or under the standard specified. For pipe 16 in. or over in diameter, the outside diameter shall not vary more than $\frac{3}{4}$ per cent over or $\frac{1}{2}$ per cent under the standard specified.

All plain end line pipe intended for Dresser or Dayton type joints, or for welding sizes $10\frac{3}{4}$ in. in outside diameter and smaller, shall not be more than $\frac{1}{64}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for the distance of 8 in. of a ring gage which has a bore $\frac{1}{16}$ in. larger than the specified outside diameter. Sizes larger than $10\frac{3}{4}$ in. in outside diameter shall not be more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for the distance of 8 in. of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter.

(*c*) *Thickness.*—The minimum wall thickness at any point shall not be more than 12.5 per cent under the wall thickness specified.

(*d*) When other than plain ends or threaded ends are ordered, permissible variations for such joints shall be agreed upon at the time of purchase.

Lengths.

13. Unless otherwise specified, pipe shall be furnished in lengths averaging 38 ft. or over, with a minimum length of 20 ft., but not more than 5 per cent may be under 32 ft.

WORKMANSHIP AND FINISH

Ends, Threads.

14. (*a*) Pipe shall be furnished with threaded ends or plain ends, as specified.

(*b*) All threads shall be in accordance with the American Standard Pipe Thread,[1] and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed one and one-half turns either way.

(*c*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be of wrought iron or steel.

(*d*) Plain end pipe for welding, unless otherwise specified, shall be beveled to an angle of 45 deg., and with a width of flat at the end of the pipe of $\frac{1}{16}$ in. ± $\frac{1}{32}$ in. This class of material shall be reamed inside at the ends sufficiently to remove all burrs. Where material is ordered beveled to any other than a 45 deg. angle, it shall be understood that the angle is to be measured from a line drawn perpendicular to the axis of the pipe.

(*e*) Plain end pipe for use with the Dresser or Dayton type coupling shall be reamed both inside and outside just sufficiently to remove any burrs or shall be beveled on the outside to an angle of 45 deg. and with an average width of flat at the end of the pipe of $\frac{1}{16}$ in. ± $\frac{1}{32}$ in. All such pipe shall be sufficiently free from indentations, projections or roll marks for a distance of 8 in. from the end of the pipe to make a tight joint with the rubber gasket type of coupling.

Finish, Defects.

15. (*a*) The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the end of the pipe shall be removed. When the depth of defect is in excess of 12½ per cent of the wall thickness, such defects shall be considered injurious.

Repairing Defects.

(*b*) The welding of injurious defects in the pipe wall, provided their depth does not exceed 33⅓ per cent of the wall thickness, shall be permitted. Defects in the welds such as sweats or leaks, unless otherwise specified, shall be repaired at the discretion of the manufacturer. Repairs of this nature shall be made by completely removing the defect, cleaning the cavity and then welding.

(*c*) All repaired pipe shall be retested hydrostatically in accordance with Section 7.

PROTECTIVE COATING

Protective Coating.

16. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating specified by the purchaser.

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[1] A complete description of American Standard Pipe Threads applicable to pipe, valves and fittings is contained in the Pipe Thread Bulletin published by the American Standards Association, A.S.A. Standard No. B 2-1919.

INSPECTION AND REJECTION

Inspection. 17. The inspector representing the purchaser shall have free entry at all time while work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 18. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
FORGE-WELDED STEEL PIPE[1]

A.S.T.M. Designation: A 136 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

1. These specifications cover steel pipe manufactured by the forge-welding process. **Scope.**

MATERIAL

2. The steel plate shall conform to the requirements for Grade A material of the Standard Specifications for Steel Plates of Structural Quality for Forge Welding (A.S.T.M. Designation: A 78) of the American Society for Testing Materials, or equally suitable weldable material as specified.[3] **Plates.**

3. (*a*) *Ladle Analysis.*—The ladle analysis made by the manufacturer of the steel shall be furnished to the purchaser when requested. **Chemical Analyses.**

(*b*) *Check Analyses.*—Analyses of two pipes in each lot of 100 lengths or fraction thereof may be made by the purchaser. The chemical composition thus determined shall conform to the requirements specified in Section 2. Drillings for analysis may be taken from the plates before rolling or from the discard ends of the finished pipe as agreed upon between the manufacturer and the purchaser. Drillings shall be taken from several points around each pipe or across each plate selected for analysis.

(*c*) *Retests.*—If the analysis of either length of pipe or plate does not conform to the requirements specified in Section 2, analyses of two additional lengths from the same lot shall be made, each of which shall conform to the requirements specified.

4. (*a*) Physical tests on two pipes from each lot of 100 lengths or fraction thereof may be made by the purchaser and shall conform to the requirements specified in Section 2. The test specimens shall **Physical Tests.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

[3] Material conforming to the Standard Specifications for Steel Plates of Flange Quality for Forge Welding (A.S.T.M. Designation: A 89) of the American Society for Testing Materials is suitable for this purpose. See 1930 Book of A.S.T.M. Standards, Part I, p. 127.

be cut longitudinally at a point 90 deg. from the weld, from the end of the pipe or plate as may be agreed upon between the manufacturer and the purchaser.

(*b*) *Retests.*—If the results of the physical tests of either specimen selected for test do not conform to the requirements specified in Section 2, retests of two additional specimens for each failure from the same lot shall be made, each of which shall conform to the requirements specified.

MANUFACTURE

Manufacture.

5. (*a*) The longitudinal edges shall be properly lapped and after heating locally from both inside and outside by means of a water-gas flame, shall be forge welded.

(*b*) After welding the longitudinal seam, each length of pipe shall be annealed in a suitable furnace and, while hot, rounded up and straightened by interior and exterior rolling.

(*c*) When pipe is specified in lengths involving the forge welding of two or more single random lengths together, each single length shall conform to the requirements specified in Paragraphs (*a*) and (*b*). Single lengths shall be joined together circumferentially by forge welding and due care shall be exercised to maintain circularity of the pipe at the weld. After welding, local normalizing shall be done, when specified, for a minimum distance of 18 in. on each side of the circumferential weld by means of a suitable annular furnace.

(*d*) The purchaser shall specify the type of joint required if the pipe is to be furnished other than with plain ends.

HYDROSTATIC TESTS

Hydrostatic Tests.

6. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D}$$

where P = the hydrostatic pressure in pounds per square inch;
S = the allowable fiber stress, 15,000 lb. per sq. in.;
t = the wall thickness in inches, and
D = the outside diameter in inches.

(*b*) While under test pressure the pipe shall be jarred with a 2-lb. hammer or its equivalent.

WEIGHTS, DIMENSIONS AND PERMISSIBLE VARIATIONS

Permissible Variations.

7. (*a*) *Weight.*—Tolerances on theoretical weights of pipe shall be governed by the weight tolerances for plates as covered in specifications of the American Society for Testing Materials to which the plates are ordered.

(*b*) *Diameter.*—The outside diameter of the pipe shall be within tolerances consistent with the method of field joints. When necessitated by the type of field joint employed for sizes 30 in. or smaller, the outside diameter of the pipe shall not be more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe and shall permit the passing for the distance of 8 in. of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter.

Length. 8. When pipe is ordered in random lengths with plain ends, lengths of 20 ft. with a variation of ± 1 ft. may be furnished. When pipe is ordered to a specified length, the tolerance shall be $\pm \frac{1}{8}$ in. When pipe with special formed ends is ordered cut to length, the tolerances shall be as agreed upon between the manufacturer and the purchaser.

WORKMANSHIP AND FINISH

Workmanship. 9. The finished pipe shall be commercially straight and round, and shall be free from injurious defects.

PROTECTIVE COATING

Protective Coating. 10. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating specified by the purchaser.

INSPECTION AND REJECTION

Inspection. 11. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 12. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
LOCK-BAR STEEL PIPE[1]

A.S.T.M. Designation: A 137 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. These specifications cover pipe suitable for the transportation of liquids or gases, made from steel plates rolled or formed into a circle, having longitudinal edges planed and upset to a dove-tail form which engages in the groove of an "H-shape" steel lock-bar to form the longitudinal joint of the pipe. After assembly of the plates and the lock-bars the latter are closed by cold-pressing, thus making a tight fit over the dove-tail edges of the plates.

MATERIAL

Plates. 2. Unless otherwise specified, the steel plate shall conform to the Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7) of the American Society for Testing Materials[3] and shall be ordered to thickness.

Lock-Bars. 3. Lock-bars shall be of open-hearth, extra-dead-soft steel conforming to the following chemical and physical requirements:

CHEMICAL COMPOSITION	
Phosphorus, maximum, per cent	0.04
Sulfur, maximum, per cent	0.05

PHYSICAL PROPERTIES	
Tensile strength, lb. per sq. in.	40 000 to 50 000
Elastic limit, minimum, lb. per sq. in.	0.5 ten. str.
Elongation in 8 in., minimum, per cent	28
Reduction of area, minimum, per cent	50
Cold bend test	180 deg. flat on itself without sign of fracture on outside of bent portion

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 67.

4. Unless otherwise specified, rivets shall be of the button-head type and shall conform to the requirements of the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials.[1] **Rivets.**

MANUFACTURE

5. (*a*) Rivet holes in the ends of plates may be punched or drilled at the option of the manufacturer. **Ends.**

(*b*) Ends of plates shall be bevel-sheared to an angle of approximately 20 deg. to form caulking edges for the circular joints.

6. The longitudinal edges of the plates shall be planed and then upset to a dove-tail form of uniform section, the wide part of which shall fit neatly into the groove of the lock-bar. Any plates splitting or otherwise showing laminations on the edges during the upsetting shall be rejected. **Upsetting of Edges.**

7. After upsetting, the longitudinal edges of the plates shall be crimped cold to the form of the finished pipe and the plates shall then be formed throughout their remaining width by cold rolling. During both operations care shall be exercised so that the dove-tail forms on the plate edges are not injured or deformed. **Forming.**

8. (*a*) In assembling the plates and lock-bars into the form of complete pipe sections, the jaws of the grooves in the lock-bars shall be closed over the dove-tail upset edges of the plates by a press with sufficient power to make the longitudinal joints of the pipe water tight and of a strength equal to that of the plate. **Pipe Assembly.**

(*b*) The lock-bars of pipe intended for the transportation of gas shall be lightly caulked along each edge.

9. (*a*) Hair line cracking of the surface of the lock-bars shall be permissible provided individual cracks are not over 3 ft. in length or $\frac{1}{16}$ in. in depth. Depth of cracks may be determined by chipping lengthwise of the crack with a flat chisel, taking off successive thin layers until bottom of the crack is reached. **Condition of Lock-Bars.**

(*b*) Where pipe is intended for lapped field joints or when flanges, bead bands or other attachment fitting into or over the end of the pipe are to be used, the lock-bar shall be scarfed off to about $\frac{1}{8}$ in. in thickness on the faying side of the pipe to permit the making of the lap joint.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 118.

Lap for Field Joints. 10. The lap of a field joint or the distance the small end enters the large end of a pipe shall depend upon the thickness and shall conform to the following requirements:

PIPE THICKNESS, IN.	WIDTH OF LAP, IN.
$\frac{3}{16}$	$1\frac{7}{8}$
$\frac{1}{4}$	$2\frac{1}{4}$
$\frac{5}{16}$	$2\frac{5}{8}$
$\frac{3}{8}$	$2\frac{7}{8}$
$\frac{7}{16}$	$3\frac{1}{4}$
$\frac{1}{2}$	$3\frac{1}{4}$

Rivets for Field Joints. 11. Field joints shall be single riveted unless otherwise specified. The number of rivets per joint shall be an even multiple of four and they shall be so located that one rivet passes through the center of each lock-bar. The diameter of rivets for field joints shall be equal to twice the thickness of the plate plus $\frac{1}{8}$ in. except that 1-in. rivets shall be used for $\frac{1}{2}$-in. plate. For the different sizes of pipe the number of rivets in single-riveted circular seams shall conform to the requirements specified in Table I.

TABLE I.—NUMBER OF RIVETS IN SINGLE RIVETED CIRCULAR SEAMS.

Thickness of Plate, in.	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	Thickness of Plate, in.	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$
Diameter of Rivets, in.	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	1	Diameter of Rivets, in.	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	1
Outside Diameter of Pipe, in.	Number of Rivets						Outside Diameter of Pipe, in.	Number of Rivets					
20	40	32	28	28	24	24	45	88	76	68	60	56	56
21	40	36	32	28	24	28	46	88	80	68	60	56	60
22	44	36	32	28	28	28	47	92	80	72	64	56	60
23	44	40	36	32	28	28	48	92	80	72	64	60	60
24	48	40	36	32	28	32	49	96	84	72	64	60	64
25	48	40	36	32	28	32	50	96	84	76	68	60	64
26	52	44	40	36	32	32	51	100	88	76	68	60	64
27	52	46	40	36	32	36	52	100	88	80	68	64	68
28	56	46	40	36	32	36	53	104	92	80	72	64	68
29	56	48	44	40	36	36	54	104	92	80	72	64	68
30	60	52	44	40	36	40	55	108	92	84	72	68	72
31	60	52	48	40	36	40	56	108	96	84	76	68	72
32	60	52	48	44	40	40	57	112	96	84	76	68	72
33	64	56	48	44	40	40	58	112	100	88	76	72	76
34	64	56	52	44	40	44	59	116	100	88	80	72	76
35	68	60	52	48	44	44	60	116	100	88	80	72	76
36	68	60	52	48	44	44	61	120	104	92	80	76	80
37	72	64	56	48	44	48	62	120	104	92	84	76	80
38	72	64	56	52	44	48	63	124	108	96	84	76	80
39	76	64	60	52	48	48	64	124	108	96	84	76	84
40	76	68	60	52	48	52	65	128	108	96	88	80	84
41	80	68	60	56	48	52	66	128	112	100	88	80	84
42	80	72	64	56	52	52	67	132	112	100	88	80	84
43	84	72	64	56	52	56	68	132	116	104	92	84	88
44	84	76	68	60	52	56	69	136	116	104	92	84	88
							70	136	120	104	96	84	88
							71	140	120	108	96	88	92
							72	140	120	108	96	88	92

HYDROSTATIC TESTS

Hydrostatic Tests.

12. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure that will stress the plate to 20,000 lb. per sq. in., provided that in no case shall the test pressure exceed 500 lb.

(*b*) While under test pressure, the lock-bars shall be struck at intervals of 5 to 6 ft. with full arm swing of a 10-lb. maul. In general, there shall be no seepage of water at the lock-bar joints but occasional slight weeping may be stopped by light caulking of the edge of the lock-bar.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Diameter.

13. The outside diameter of the pipe shall be within tolerances consistent with the method of field joints. When necessitated by the type of field joint employed for sizes 30 in. or smaller, the outside diameter of the pipe shall not be more than $\frac{1}{32}$ in. smaller than the specified outside diameter for a distance of 8 in. from the end of the pipe, and shall permit the passing, for the distance of 8 in., of a ring gage which has a bore $\frac{3}{32}$ in. larger than the specified outside diameter.

Thickness.

14. Unless otherwise provided for in the contract, the purchaser shall specify the wall thickness. The strength of the lock-bar longitudinal joint shall be assumed as 100 per cent.

Length.

15. Unless otherwise specified, the standard length shall be not less than 30 ft.

PROTECTIVE COATING

Protective Coating.

16. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating specified by the purchaser.

PACKING

Packing.

17. After the pipe has been coated, it shall be handled carefully in such manner as will not injure or mar the coating and so loaded on cars or trucks as to prevent contact of pipe with other pipe or with stakes or saddles. Burlap pads shall be well secured to prevent shifting in transportation.

INSPECTION AND REJECTION

Inspection.

18. The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford

the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 19. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS

FOR

RIVETED STEEL AND WROUGHT-IRON PIPE[1]

A.S.T.M. Designation: A 138 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. These specifications cover shop-fabricated straight pipe made from steel or wrought-iron plates with riveted seams.

MATERIAL

Plates. 2. (*a*) Unless otherwise specified, the steel plate shall be of open-hearth steel, conforming to the Standard Specifications for Structural Steel for Bridges (A.S.T.M. Designation: A 7) of the American Society for Testing Materials,[3] and shall be ordered to thickness.

(*b*) If wrought-iron plates are specified they shall conform to the Standard Specifications for Wrought-Iron Plates (A.S.T.M. Designation: A 42) of the American Society for Testing Materials.[4]

Rivets. 3. Unless otherwise specified, rivets shall be of open-hearth steel conforming to the Standard Specifications for Boiler Rivet Steel (A.S.T.M. Designation: A 31) of the American Society for Testing Materials.[5]

MANUFACTURE

Type of Joint. 4. (*a*) Standard pipe shall be made of in-and-out courses, unless tapered courses are specified by the purchaser.

(*b*) Edges of plates less than $\frac{5}{8}$ in. in thickness which are to be caulked shall be beveled.

(*c*) At the junction of longitudinal and circular joints, the middle plate shall be properly scarfed.

Rivet Holes. 5. (*a*) All rivet holes for butt-joint pipe and for lap-joint pipe, where the plate thickness exceeds $\frac{1}{2}$ in. shall be sub-punched $\frac{1}{8}$ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 67.

[4] *Ibid.*, p. 452.

[5] *Ibid.*, p. 118.

smaller and reamed to size or drilled full size. The diameter of the finished rivet hole shall be $\frac{1}{16}$ in. greater than the specified diameter of the rivet.

(*b*) The diameter of the die shall not exceed the diameter of the punch by more than $\frac{1}{16}$ in. All burrs shall be removed. Punched holes shall be spaced true to line, so that when the plate edges are brought together the holes will match properly.

(*c*) A sufficient number of rivet pass-holes shall be provided at convenient places and shall be equipped with proper size plugs for closing the same.

(*d*) Drift pins may be used only for drawing the material together. Their use to enlarge unfair holes will not be permitted. Necessary corrections to ensure matching of holes shall be made with a reamer.

Forming. 6. All plates shall be formed cold to as nearly a true circle as practicable.

Pipe Assembly. 7.(*a*) *Riveting.*—All rivets shall be machine driven, either by hydraulic or pneumatic riveting machines, exerting a slow steady pressure sufficient to form a strong and tight rivet joint. All rivets after being driven shall completely fill the hole and shall have full heads concentric with the shank. All loose, burned, or otherwise defective rivets shall be cut out and replaced. Care shall be exercised not to damage the adjacent material when cutting out rivets.

(*b*) *Caulking.*—Unless otherwise specified, all straight pipe shall be caulked, both inside and outside. All caulking shall be done with a round-nosed tool. No split caulking shall be permitted. When so specified, the joints may be made tight by welding instead of caulking.

HYDROSTATIC TESTS

Hydrostatic Tests. 8. (*a*) Each length of pipe shall be tested at the mill to a hydrostatic pressure calculated from the following formula:

$$P = \frac{2\,St}{D} \times e$$

where P = the hydrostatic pressure in pounds per square inch;
S = the allowable fiber stress (maximum 22,000 lb. per sq. in.);
t = the wall thickness in inches;
D = the outside diameter in inches; and
e = the efficiency of the joint.

(*b*) All leaks shall be made tight under test. Sweating of rivets and seams under pressure shall not be considered leaks.

DIMENSIONS

9. Unless otherwise specified, pipe shall be fabricated in shipping lengths of 30 ft. or over, but each length shall be made of not more than four courses. **Length.**

PROTECTIVE COATING

10. After the pipe has been subjected to the hydrostatic test, and if required by the purchaser, it shall be thoroughly cleaned of all dirt, oil, grease, loose scale, and rust; dried; and shall then be given a protective coating specified by the purchaser. **Protective Coating.**

INSPECTION AND REJECTION

11. The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

12. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified. **Rejection.**

TENTATIVE SPECIFICATIONS

FOR

FERRO-MOLYBDENUM[1]

A.S.T.M. Designation: A 132 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. These specifications cover the standard grade of ferro-molybdenum only.

Basis of Purchase. 2. Unless otherwise specified, ferro-molybdenum shall be furnished crushed to a size 1 in. and less.

Chemical Composition. 3. (*a*) The material shall conform to the following requirements as to chemical composition:

Carbon, maximum	2.50	per cent
Molybdenum	50.00 to 60.00	"
Sulfur, maximum	0.25	"
Phosphorus, maximum	0.10	"
Copper, maximum	0.25	"

(*b*) The manufacturer shall furnish an analysis of each shipment showing the molybdenum content and when required such of the other elements specified in Paragraph (*a*).

Sampling. 4. The sampling shall be carried out in accordance with the procedure for High-Carbon Ferro-Chromium, Chromium Metal, Low-Carbon Ferro-Manganese and Manganese Metal described in the Standard Methods of Sampling Ferro-Alloys (A.S.T.M. Designation: A 103) of the American Society for Testing Materials.[3]

Packing. 5. Ferro-molybdenum shall be packed in sound containers in such manner that none of the metal is lost in shipment.

Inspection. 6. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the sampling, packing and shipping of material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Charles McKnight, Secretary of Committee A-9 on Ferro-Alloys, International Nickel Co., 67 Wall Street, New York City.

[2] Approved for publication as tentative by Committee E-10 on Standards, February 20, 1931.

[3] 1930 Book of A.S.T.M. Standards, Part I, p. 543.

(*b*) If the purchaser so elects the material may be sampled by him at the destination, in which case at least 10 per cent of the containers shall be sampled.

Rejection.

7. Any claims or rejections based on check analysis shall be made within 30 days from receipt of material.

TENTATIVE DEFINITIONS OF TERMS, WITH UNITS AND SYMBOLS, RELATING TO MAGNETIC TESTING[1]

A.S.T.M. Designation: A 127 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1929; REVISED, 1930, 1931.

In the following list of definitions the term defined is given first followed in parenthesis by any optional alternative terms which may be used when the context clearly indicates the intended conception. The symbol for the quantity is then given wherever such symbol is in use, followed by the definition of the standard term.

The name of the unit employed is included, together with the definition of the unit.

Basic Conceptions

Magnetic Field (*Field*).—The region in space in which a magnetic state exists.

UNIT: None.

Magnetic Circuit.—A closed path of magnetic flux.

Magnetic Flux (*Flux*), Φ.—The magnetic quantity which by its variation is capable of producing in an associated electric circuit an electromotive force proportional to its time rate of variation.

UNIT: *Maxwell.*—The maximum value of the magnetic flux, the uniform variation of which between zero and its full value in one second induces one c.g.s. unit of electromotive force in a single turn electric circuit enclosing the flux.

Magnetomotive Force, $\mathcal{F}$.—The total magnetizing influence acting on any part of a magnetic circuit.

UNIT: *Gilbert.*—The magnetomotive force resulting from a current in an electric circuit of any number of turns linked with the magnetic circuit when the product of the current in amperes by the number of turns is $\frac{1}{0.4\pi}$.

NOTE.—When a current of I amperes is flowing in a circuit of N turns, $\mathcal{F} = 0.4\,\pi\,NI$.

Derived Conceptions

Magnetic Force (*Magnetizing Force, Field Intensity*), H.—The space rate of variation of magnetomotive force at any point in the magnetic circuit.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

UNIT: *Oersted.*—The magnetic force of one gilbert per centimeter.

NOTE.—At the center of an infinitely long solenoid having n turns per centimeter in which a current of I amperes is flowing, $H = 0.4 \pi n I$.

Magnetic Potential Difference.—The magnetomotive force between two points.

Induction (Flux Density), B.—The flux per unit area normal to the direction of the flux.

UNIT: *Gauss.*—An induction of one maxwell per square centimeter.

Normal Induction, B.—The induction in a magnetic material corresponding to a given magnetic force when the material is in a symmetrically cyclic magnetic condition with respect to the given magnetic force.

UNIT: Same as for *Induction.*

Intrinsic Induction (Ferric Induction), B_i.—The excess of the normal induction over that corresponding to the same magnetic force in empty space.

UNIT: Same as for *Induction.*

Saturation Induction, B_s.—The maximum intrinsic induction possible in a material.

UNIT: Same as for *Induction.*

Permeability, μ.—When used without a qualifying adjective, understood to be the normal permeability as defined below.

UNIT: None.

Normal Permeability, μ.—The ratio of the normal induction to the corresponding magnetic force.

UNIT: None.

Initial Permeability, μ_o.—The normal permeability when both the magnetic force and the induction are vanishingly small.

UNIT: None.

Differential Permeability, μ_d.—The ratio of the positive increase of normal induction to the positive increase of magnetic force when these increases are vanishingly small.

UNIT: None.

Incremental Permeability, μ_Δ.—The ratio of the cyclic change in induction to the corresponding cyclic change in magnetic force when the mean induction differs from zero.

UNIT: None.

Reversible Permeability, μ_r.—The incremental permeability when the change in induction is vanishingly small.

UNIT: None.

Intrinsic Permeability, μ_i.—The ratio of the intrinsic induction to the corresponding magnetic force.

UNIT: None.

Permeance, $\mathscr{P}$.—The property of any part of a magnetic circuit which determines the flux corresponding to a given magnetomotive force.

NOTE.—Permeance $= \frac{\Phi}{\mathscr{F}}$ equivalent to $\frac{\mu A}{l}$ for uniform μ.

where μ = permeability;
A = area in square centimeters; and
l = length in centimeters.

UNIT: None.

Reluctivity.—The reciprocal of permeability.

UNIT: None.

Reluctance, $\mathscr{R}$.—The reciprocal of permeance.

NOTE.—Reluctance $= \frac{\mathscr{F}}{\Phi} = \frac{l}{\mu A}$ for uniform μ.

UNIT:—The reluctance of a portion of an empty space one centimeter in length and having a cross-section of one square centimeter.

Remanence.—The magnetic induction which remains in a magnetic circuit after the removal of an applied magnetic force.

NOTE.—If there is an air gap in the magnetic circuit, the remanence will be less than the residual induction.

UNIT: Same as for *Induction*.

Residual Induction, B_r.—The magnetic induction which remains in a magnetic material when the effective magnetic force has been reduced to zero.

NOTE.—When the material is in a symmetrically cyclic magnetic condition, the residual induction is called the *normal* residual induction.

UNIT: Same as for *Induction*.

Retentivity.—The property of a material measured by the normal residual induction remaining after the removal of an applied magnetic force corresponding to the saturation induction for the material.

UNIT: Same as for *Induction*.

Coercive Force, H_c.—The reversed magnetic force that is just sufficient to reduce the residual induction in a material to zero.

Note.—When the residual induction is the *normal* residual induction, the coercive force required is called the *normal* coercive force.

Unit: Same as for *Magnetic Force.*

Coercivity.—The property of a material measured by the coercive force required to reduce to zero the induction remaining after the removal of an applied magnetic force corresponding to the saturation induction for the material.

Unit: Same as for *Magnetic Force.*

Core Loss (*Iron Loss*), W.—The power expended in a magnetic material subjected to a varying induction.

Eddy Current Loss, W_e.—The part of the core loss due to currents circulating in the magnetic material as a result of electromotive forces induced by the varying induction.

Hysteresis Loss, W_h.—That part of the core loss due to so-called hysteresis effects.

Standard Core Loss, $W_{B/f}$.—The total power in watts per kilogram expended in the magnetic material which is subjected to a harmonically varying induction of a specified maximum value B and of a specified frequency f.

Aging (of magnetic materials).—The normal or accelerated change in magnetic properties of a magnetic material under continued normal or specified artificial aging conditions. When used in reference to core loss this term, unless otherwise modified, implies an increase in loss. When used in reference to permeability or remanence the term, in a positive sense, indicates a decrease in these quantities.

Diamagnetic.—Having a magnetic permeability less than unity.

Paramagnetic.—Having a magnetic permeability slightly greater than unity and approximately independent of the magnetic induction.

Ferromagnetic.—Having a magnetic permeability considerably greater than unity.

Linkage.—The product of the flux in maxwells and the number of turns in a coil or winding linked therewith.

TENTATIVE SPECIFICATIONS
FOR
MAGNESIUM-BASE ALLOY CASTINGS[1]

A.S.T.M. Designation: B 80 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1930; REVISED, 1931.

Scope. 1. These specifications cover commercial magnesium-base alloy sand castings having a specific gravity of 1.9 or less. Three typical alloys are specified and are designated Alloys Nos. 1, 2 and 3.

MANUFACTURE

Process. 2. The alloy may be made from virgin metal or from purified scrap metal of known composition.

Heat Treatment. 3. Castings made from Alloy No. 2 may be subjected to such heat treatment as the manufacturer desires to produce material that will conform to the requirements specified. Heat treatment shall be performed on the whole of a casting, never on a part only, and shall be applied in a manner that will produce the utmost uniformity.

CHEMICAL COMPOSITION

Chemical Composition. 4. The alloys shall conform to the following requirements as to chemical composition:

Alloy	Magnesium, per cent	Aluminum, per cent	Manganese minimum, per cent	Copper, per cent	Cadmium, per cent	Other Impurities, maximum, per cent
No. 1	remainder	5.5 to 7.0	0.2	0.1, max.	....	0.3
No .2	remainder	6.5 to 8.5	0.2	0.1, max.	....	0.3
No. 3	remainder	1.7 to 2.3	0.2	3.5 to 4.5	1.6 to 2.4	0.3

Chemical Analysis. 5. (*a*) The sample for chemical analysis may be taken by sawing, drilling, or milling the casting or tension test specimen and shall represent the average cross-section of the piece.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Gann, Secretary of Committee B-7 on Light Metals and Alloys, Cast and Wrought, The Dow Chemical Co., Midland, Mich.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

(*b*) The saw, drill, cutter, or other tool shall be thoroughly cleaned. No lubricant shall be used in the sampling operation.

PHYSICAL PROPERTIES AND TESTS

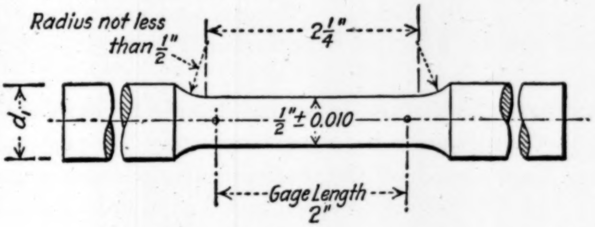
Tensile Requirements.

6. The castings shall conform to the following requirements as to tensile properties:

ALLOY	CONDITION	TENSILE STRENGTH, MINIMUM, LB. PER SQ. IN.	ELONGATION IN 2 IN., MINIMUM, PER CENT
No. 1	Sand Cast	24 000	4
No. 2	Sand Cast	24 000	4
	Sand Cast, Heat Treated	29 000	6
No. 3	Sand Cast	21 000	2

Test Specimens.

7. The test bars shall be separately cast in green sand and shall be "cast to size" according to the dimensions shown in Fig. 1. They shall not be machined prior to test except to adapt the grips to the holders of the testing machine in such a manner as to insure an axial load.



NOTE:

The Gage Lengtn, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way, that the Load shall be Axial.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d_1 be from $\frac{3}{4}$" to 1."

FIG. 1.—Tension Test Specimen.

Number of Tests.

8. (*a*) The tests shall, so far as possible, be made by heats or melts, but unless otherwise agreed upon, two tension tests shall be made for each unit of 500 lb. or fraction thereof.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser, or his representative, shall agree upon the selection of another specimen in its stead.

WORKMANSHIP AND FINISH

Workmanship and Finish. 9. The castings shall be of uniform quality and condition, free from cracks or other injurious defects, and shall be well cleaned before inspection by sand-blasting, tumbling, chipping, pickling in sulfuric acid, or other approved process.

INSPECTION AND REJECTION

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspecter, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES

Alloy No. 1.—Alloy No. 1 has a specific gravity of about 1.78. It is used only in the as-cast condition. The copper content should be kept as low as possible in order to minimize corrosion.

Alloy No. 2.—Alloy No. 2 has a specific gravity of about 1.80. It is susceptible to heat treatment and is used both in the as-cast and heat-treated conditions. The most beneficial effects of heat treatment are reflected in the increase in tensile strength, percentage of elongation and notched-bar impact toughness. The copper content should be kept as low as possible in order to minimize corrosion.

Alloy No. 3—Alloy No. 3 has a specific gravity of about 1.82. Its thermal conductivity is 50 to 75 per cent greater than that of Alloys Nos. 1 and 2 and is recommended where this property is of great importance.

TENTATIVE SPECIFICATIONS
FOR
COPPER-BASE ALLOYS IN INGOT FORM FOR SAND CASTINGS[1]

A.S.T.M. Designation: B 30 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1919; ADOPTED IN AMENDED FORM, 1922;
REISSUED AS TENTATIVE, 1928; REVISED, 1930, 1931.[2]

Scope. 1. These specifications cover copper-base alloys in ingot form for sand castings in twenty different compositions, regularly sold by the trade and arbitrarily herein given numbers 1 to 20, inclusive, to differentiate them from one another. These numbers have no other significance.

MANUFACTURE

Quality. 2. The manufacturer shall use care to have each lot of ingot metal as uniform in quality as possible. This metal may be manufactured by any refining process which will yield a satisfactory quality of product.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The alloys shall conform to the requirements as to chemical composition given in Table I, within the limits specified therein.

NOTE.—The limits specified in Table I indicate the maximum and minimum percentages within which variations of different elements shall be permitted, with the understanding that every precaution shall be taken both in the selection of raw materials as well as methods of manufacture to insure that the resulting ingot metal will come within these specified limits.

Samples for Chemical Analysis. 4. (*a*) Ten ingots shall be selected by the inspector to represent each 40,000 lb. and five ingots shall be selected for less than carload lots.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Chase Brass and Copper Co., Inc., Waterbury, Conn.

These tentative specifications are, in effect, a revision of the former Standard Specifications for Brass Ingot Metal, Graded and Ungraded, for Sand Castings (A.S.T.M. Designation: B 30 – 22), which specifications were discontinued in 1928.

[2] Revision approved by Committee E-10 on Standards, August 6, 1931.

(*b*) The samples for chemical analysis may be taken by drilling the ingots and shall represent the average cross-section of all of the ingots selected for sampling.

TABLE I.—CHEMICAL COMPOSITIONS OF COPPER-BASE ALLOYS.

Alloy Grade	Copper, per cent		Tin, per cent			Lead, per cent			Zinc, per cent			Phosphorus, maximum, per cent	Other Elements, maximum, per cent						Total Constituents, per cent	
	Minimum	Desired	Minimum	Desired	Maximum	Minimum	Desired	Maximum	Minimum	Desired	Maximum		Antimony	Iron	Nickel	Sulfur	Aluminum[a]	Silicon	Other than Copper, Lead, Tin, Zinc and Nickel	Other than Copper, Lead, Tin, Zinc, Nickel and Antimony
Bronze Alloys																				
No. 1	87	89	5.5	6	6.5	1.5	2	2.5	2	3	4	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 2	84	85	9	10	11	1.5	2	2.5	1.5	2	2.5	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 3	84	85	7.25	8	8.75	1.5	2	2.5	3.5	4	4.5	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
Red Brass Alloys																				
No. 4	84	85	4.5	5	5.5	4.5	5	5.5	4.5	5	5.5	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 5	83	85	4.25	5	5.75	4.25	5	5.75	4.25	5	5.75	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
No. 6	82	83	6.25	7	7.75	6.25	7	7.75	2	3	...	0.03	0.25	0.25	0.50	0.08	none	0.05	0.50	....
Semi Red Brass Alloys																				
No. 7	83	84	2.5	3	3.5	2.5	3	3.5	9	10	11	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
No. 8	82	83	3.25	4	4.75	5	6	7	5	7	...	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
No. 9	79	80	2.5	3	3.5	6.25	7	7.75	7.5	9.5	...	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
No. 10	77	78	2.5	3	3.5	4.25	5	5.75	11	13.5	...	0.03	0.25	0.35	0.50	0.08	none	0.05	0.50	....
Yellow Brass Alloys																				
No. 11	70	71	1	1.5	2	2	3	4	20	24	...	0.01	0.10	0.30	0.50	0.05	none	0.10	0.50	....
No. 12	67	69	0	0	1.5	2	3	4	25	27	...	0.01	0.10	0.30	0.50	0.05	none	0.10	0.50	....
No. 13	64	66	0	0	1	1	2	3	30	31	...	0.01	0.10	0.30	0.50	0.05	none	0.10	0.50	....
No. 14	60	62	0	0	1	1	2	3	30	35	...	0.01	0.10	0.30	0.50	0.05	0.50	0.10	1.00	....
High Lead Alloys																				
No. 15	84	85	4.25	5	5.75	8	9	10	0.5	1	2	0.01	0.25	0.25	0.50	0.08	none	0.03	....	0.50
No. 16	79	80	9	10	11	9	10	11	...	...	0.25	0.05[b]	0.50	0.25	0.25	0.08	none	0.03	....	0.50
No. 17	76	77	9	10	11	9	10	11	...	0.75	1	0.01	0.50	0.25	0.50	0.08	none	0.03	....	0.50
No. 18	72	73	7	8	9	13.5	15	16.5	1	1.5	2	0.05	1.00	0.25	0.50	0.08	none	0.03	....	0.50
No. 19	71	71.5	3.5	4.5	5.5	14	17	20	2	4	6	0.05	1.00	0.25	0.50	0.08	none	0.03	....	0.50
No. 20	70	70.5	5.25	6	6.75	18	20	22	0.5	1	1.5	0.05	1.00	0.25	0.50	0.08	none	0.03	....	0.50

[a] The term "none" as applied to Aluminum allowance is defined as a maximum of 0.005 per cent when determined in accordance with Section 5.

[b] Minimum.

(*c*) The drill used shall be thoroughly cleaned. No lubricant shall be used in the operation and the drillings shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

Methods of Chemical Analysis. 5. The chemical analysis shall be made in accordance with the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (A.S.T.M. Designation: B 45) of the American Society for Testing Materials.[1]

Marking. 6. The designating mark of the manufacturer, the proper lot number, and the numerical designation of the alloy shall be marked on each ingot for identification.

INSPECTION AND REJECTION

Inspection. 7. (*a*) Inspection may be made at the manufacturer's works, where the ingots are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 8. If the test ingots selected to represent a lot fail to conform to the requirements specified in Section 3 all ingots in such lot shall be rejected.

CLAIMS

Claims. 9. Claims, to be considered, shall be made in writing within 30 days of receipt of material at the purchaser's plant and the results of the purchaser's tests shall be given. The manufacturer shall, within one week of receipt of such claim, either agree to satisfy the claim, or send a representative to the purchaser's plant to resample the shipment in accordance with Section 4. Samples so taken shall be sealed and submitted to a mutually agreeable umpire whose determinations shall be final.

Settlement of Claims. 10. The expense of umpire analysis shall be paid by the loser or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of ingot metal conforming to these specifications.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 837.

APPENDIX

The data in the following tables do not constitute a part of these specifications. They are given merely to indicate to the purchaser the approximate physical properties of the various alloys specified, that may be expected of carefully manufactured alloys of the formulas indicated and to constitute a guide to the purchaser in selecting the alloy grade best suited for meeting the service conditions for which the ingot metal is to be used.

Alloy Grade	Tensile Strength,[a] lb. per sq. in.	Elongation in 2 in., per cent	Reduction of Area, per cent	Compression Deformation Limit,[b] lb. per sq. in.	Brinell Hardness (500 kg. for 30 seconds)	Pattern Maker's Allowance for Shrinkage, in. per ft.	Weight, lb. per cu. ft.
			BRONZE ALLOYS				
No. 1	30 000 to 40 000	15 to 30	15 to 30	......	44 to 48	0.1875	535
No. 2	32 000 to 38 000	15 to 20	15 to 20	......	55 to 65	0.1875	535
No. 3	30 000 to 36 000	25 to 30	25 to 30	......	55 to 65	0.1875	535
			RED BRASS ALLOYS				
No. 4	27 000 to 33 000	15 to 20	15 to 20	......	50 to 60	0.1875	535
No. 5	27 000 to 33 000	15 to 20	15 to 20	......	50 to 60	0.1875	535
No. 6	26 000 to 32 000	13 to 19	14 to 21	......	50 to 60	0.1875	540
			SEMI RED BRASS ALLOYS				
No. 7	31 000 to 37 000	25 to 35	20 to 30	......	50 to 60	0.1875	535
No. 8	29 000 to 35 000	25 to 35	20 to 30	......	40 to 50	0.1875	535
No. 9	22 000 to 28 000	10 to 15	10 to 15	......	50 to 55	0.1875	540
No. 10	25 000 to 30 000	15 to 25	20 to 25	......	45 to 55	0.1875	540
			YELLOW BRASS ALLOYS				
No. 11	30 000 to 35 000	35 to 45	25 to 35	......	40 to 50	0.1875	535
No. 12	30 000 to 35 000	25 to 35	20 to 30	......	40 to 50	0.1875	535
No. 13	30 000 to 35 000	25 to 35	20 to 30	......	40 to 50	0.1875	533
No. 14	30 000 to 45 000	15 to 25	20 to 30	......	40 to 50	0.250	500
			HIGH LEAD ALLOYS				
No. 15	25 000 to 31 000	8 to 13	7 to 13	12 000	45 to 55	0.1875	540
No. 16	27 000 to 33 000	7 to 12	8 to 13	12 500	47 to 52	0.1875	553
No. 17	27 000 to 33 000	7 to 10	7 to 12	12 500	47 to 52	0.1875	553
No. 18	25 000 to 30 000	11 to 17	10 to 16	12 000	45 to 50	0.1875	570
No. 19	25 000 to 30 000	10 to 15	7 to 13	12 000	47 to 52	0.1875	570
No. 20	22 000 to 27 000	10 to 16	7 to 13	11 000	42 to 47	0.1875	570

[a] The tension tests were made on test specimens taken from ingots, except Alloys Nos. 7 and 15, which were sand cast. Sand-cast test specimens would show somewhat lower values.

[b] The compression tests were made on machined test specimens (sand castings) of 1 sq. in. sectional area, 1 in. high. The compression deformation limit is taken as the load producing a compression in the specimen of 0.001 in. At the request of Committee B-2 on Non-Ferrous Metals and Alloys, Committee E-1 on Methods of Testing is giving consideration to revising the dimensions of compression test specimens and the method of determining the so-called "compression deformation limit." The revision of the values in this column, on the basis of cylindrical specimens 1 sq. in. in sectional area and 3 in. high is contemplated. A revision of the methods of determining compression deformation limit is also under consideration.

Alloy Grade	Examples of Use	Foundry Manipulation	Characteristics
	Bronze Alloys		
No. 1	For valves and fittings for steam, gas, etc.	Requires careful foundry practice	Machines well
No. 2	Commercial bronze for high-duty bearings where wear resistance is essential	Requires careful foundry practice	Machines well
No. 3	Good-strength hard bronze for general service	Requires careful foundry practice	Machines well
	Red Brass Alloys		
No. 4	High-grade red brass for general service	Foundry practice not difficult	Machines well
No. 5	Second-grade red brass for general service	Foundry practice not difficult	Machines well
No. 6	Auto fittings, carburetor parts	Foundry practice not difficult	Machines well
	Semi Red Brass Alloys		
No. 7	Catenary fittings, overhead fittings Electric Railways; very resistent to atmospheric corrosion	Foundry practice not difficult	Machines well
No. 8	Reddish yellow alloy for air, gas and water fittings	Foundry practice not difficult	Machines well
No. 9	Valve fittings for low pressure	Foundry practice not difficult	Machines well
No. 10	Yellowish red alloy for air, gas and water fittings	Foundry practice not difficult	Machines well
	Yellow Brass Alloys		
No. 11	Yellowish red alloy for plumbers' fittings	Foundry practice not difficult	Machines well
No. 12	Yellow brass for light castings and ornamental work not requiring strength or subjected to internal pressure	Foundry practice not difficult	Machines well
No. 13	Yellow brass for heavier castings	Foundry practice not difficult	Machines well
No. 14	Plumbers' flanges, scupper pipes, etc.	Very difficult. Aluminum up to 0.30 per cent improves casting properties, but increases shrinkage	Hard to machine. Not suitable for bearings or water pressure fittings
	High Lead Alloys		
No. 15	Small bearings such as automobile bearings and bushings, machined by broaching	Foundry practice not difficult	Machines easily
No. 16	Bearings for heavy pressure. Not machined by broaching	Foundry practice not difficult	Machines easily
No. 17	Hard bearing metal for small bushings, to be machined by broaching, harder than No. 15	Foundry practice not difficult	Machines easily
No. 18	Locomotive engine castings and general service bearings for moderate pressure	Foundry practice not difficult	Machines easily
No. 19	Car journal bearings and similar service	Foundry practice not difficult	Machines easily
No. 20	Bearings operated at high speed and under light or medium pressure	Foundry practice not difficult	Machines easily

TENTATIVE SPECIFICATIONS
FOR
DRAWN OR ROLLED ALLOY, 80 PER CENT NICKEL, 20 PER CENT CHROMIUM, FOR ELECTRICAL HEATING ELEMENTS[1]

A.S.T.M. Designation: B 82 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover annealed, drawn, or rolled shapes for electrical heating element purposes having a nominal chemical composition of 80 per cent nickel and 20 per cent chromium.

Treatment. 2. Wire and ribbon shall be thoroughly and uniformly annealed.

CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The material shall conform to the following requirements as to chemical composition:

Nickel,[a] per cent	77 to 79
Chromium, per cent	19 to 20
Iron, maximum, per cent	1.5
Manganese, maximum, per cent	2.5
Carbon, maximum, per cent	0.25
Silicon, maximum, per cent	0.40
Sulfur, maximum, per cent	0.03

[a] Small quantities of cobalt included shall be reported as nickel.

Sample for Chemical Analysis. 4. Samples for chemical analysis shall consist of clean drillings, millings, or clippings taken from the wire or ribbon selected for purposes of test. The sample shall be taken from a spool or coil representative of the lot in question. The sample so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

Chemical Analysis. 5. Chemical analyses shall be determined in accordance with the Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (A.S.T.M. Designation: B 71 - 29 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, Driver-Harris Co., Harrison, N. J.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 593 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 183.

PHYSICAL PROPERTIES AND TESTS

Elongation. 6. Wire of No. 39 A.w.g. (0.0035 in.) and larger shall have a minimum elongation of 20 per cent in 10 in., and from Nos. 40 to 44 A.w.g. (0.0031 to 0.002 in.), a minimum elongation of 10 per cent.

Specific Resistance. 7. (*a*) The nominal specific resistance of the round wire shall be taken as 650 ohms per circular mil foot (108 microhms per centimeter cube) at 77° F. (25° C.).

(*b*) The nominal specific resistance of the ribbon shall be taken as 510 ohms per square mil foot (108 microhms per centimeter cube) at 77° F. (25° C.).

Test Procedure for Resistivity. 8. The specific resistance shall be determined in accordance with the Standard Method of Test for Resistivity of Metallic Materials for Resistors (A.S.T.M. Designation: B 63) of the American Society for Testing Materials.[1]

Resistance per Foot. 9. (*a*) *Round Wire.*—The resistance per foot of round wire shall be calculated from the nominal specific resistance and the cross-section of the material. The limits on resistance per foot shall be as follows:

No. 30 A. w. g. (0.0100 in.) and larger	±5 per cent
No. 31 to 40 A. w. g. (0.0089 to 0.0031 in.)	±8 per cent
No. 40 A. w. g. (0.0031 in.) and smaller	±10 per cent

(*b*) *Strip Material.*—The resistance per foot of strip material shall be calculated from the nominal specific resistance and the cross-section of the material. In order to compensate for error in the calculated cross-section on ribbon with rounded edges, the calculated values arrived at by multiplying the nominal width by nominal thickness shall be corrected by multiplying by the factor indicated in the following table:

RATIO OF WIDTH TO THICKNESS	FACTOR
15 and under	0.94
Over 15	0.83

Resistance Increase with Temperature. 10. Temperature coefficient of resistance shall, after the wire has been slowly cooled from an annealing temperature, be measured in accordance with the Standard Method of Test for Change of Resistance with Temperature of Metallic Materials for Electrical Heating (A.S.T.M. Designation: B 70) of the American Society for Testing Materials.[2] The temperature coefficient of resistance shall be such as will bring the resistance within ± 20 per cent of the following:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 869.

[2] *Ibid.*, p. 872.

TEMPERATURE	RESISTANCE, PER CENT
77° F. (25° C.)	100.0
800° F. (427° C.)	103.7
1000° F. (539° C.)	104.0
1200° F. (649° C.)	103.3
1400° F. (760° C.)	103.2
1600° F. (871° C.)	103.6
1800° F. (980° C.)	104.1
2000° F. (1094° C.)	104.8

Durability. 11. (*a*) When it is desired to determine the durability of the material at high temperatures, life tests shall be made in accordance with the Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (A.S.T.M. Designation: B 76 – 29 T) of the American Society for Testing Materials.[1] Test results shall be reported as a percentage of a standard of comparison.

(*b*) The life or durability value shall be the average of at least three simultaneous determinations each, on the wire in question and on the standard. If any test result varies more than 10 per cent from the average of the three determinations, that group shall be discarded.

FINISH

Finish. 12. The material shall be as uniform and free from surface defects such as splits, kinks, laminations, scale, and other irregularities as the best commercial practice will permit. Finish shall be either bright annealed or oxidized, as specified.

PACKING AND MARKING

Packing. 13. (*a*) *Round Wire or Rod.*—Round wire or rod in sizes No. 16 A.w.g. or larger shall be supplied in coils consisting of not more than two pieces per 40-lb. coil. Round wire sizes smaller than No. 16 gage shall be supplied in spools containing not more than two pieces and shall be spooled in accordance with the following requirements:

WEIGHT OF WIRE, LB.	SPOOL DIMENSIONS			
	DIAMETER OF FLANGE, IN.	TRAVERSE, IN.	DIAMETER OF HOLE, IN.	DIAMETER OF BARREL, IN.
1	2	3	5/8	1¼
2	2¾	3	5/8	1½
5	4	3	5/8	1½
10	6	3	5/8	1¾
25	9	4	1	3¾

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 613 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 208.

(*b*) *Ribbon.*—Ribbon over ¼ in. in width shall be supplied in coils containing not more than one piece, and shall be securely wrapped so as to avoid injuring the edges of the strips. Ribbon of ¼ in. in width or narrower, shall be supplied on suitable spools containing not more than two pieces per spool.

14. Coils or spools shall be marked with the size and resistance per foot and a yellow tag or label shall be used to indicate this alloy. **Marking.**

TENTATIVE SPECIFICATIONS
FOR
DRAWN OR ROLLED ALLOY, 60 PER CENT NICKEL, 15 PER CENT CHROMIUM, AND BALANCE IRON, FOR ELECTRICAL HEATING ELEMENTS[1]

A.S.T.M. Designation: B 83 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover annealed, drawn, or rolled shapes for electrical heating element purposes having a nominal chemical composition of 60 per cent nickel, 15 per cent chromium and the balance iron.

Treatment. 2. Wire and ribbon shall be thoroughly and uniformly annealed.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 3. The material shall conform to the following requirements as to chemical composition:

Nickel,[a] minimum, per cent	57
Chromium, per cent	14 to 18
Iron, per cent	balance
Manganese, maximum, per cent	3
Silicon, maximum, per cent	0.40
Carbon, maximum, per cent	0.25
Sulfur, maximum, per cent	0.03

[a] Small quantities of cobalt included shall be reported as nickel.

Sample for Chemical Analysis. 4. Samples for chemical analysis shall consist of clean drillings, millings, or clippings taken from the wire or ribbon selected for purposes of test. The sample shall be taken from a spool or coil representative of the lot in question. The sample so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the manufacturer, one for the purchaser, and one for an umpire, if necessary.

Chemical Analysis. 5. Chemical analyses shall be determined in accordance with the Tentative Methods of Chemical Analysis of Metallic Materials for Electrical Heating (A.S.T.M. Designation: B 71 – 29 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, Driver-Harris Co., Harrison, N. J.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 593 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 183.

PHYSICAL PROPERTIES AND TESTS

Elongation.

6. Wire of No. 39 A.w.g. (0.0035 in.) and larger shall have a minimum elongation of 20 per cent in 10 in. and from Nos. 40 to 44 A.w.g. (0.0031 to 0.002 in) a minimum elongation of 10 per cent.

Specific Resistance.

7. (*a*) The nominal specific resistance of round wire shall be taken as 675 ohms per circular mil foot (112.22 microhms per centimeter cube) at 77° F. (25° C.).

(*b*) The nominal specific resistance of the ribbon shall be taken as 530 ohms per square mil foot (112.22 microhms per centimeter cube) at 77° F. (25° C.).

Test Procedure for Resistivity.

8. The specific resistance shall be determined in accordance with the Standard Method of Test for Resistivity of Metallic Materials for Resistors (A.S.T.M. Designation: B 63) of the American Society for Testing Materials.[1]

Resistance per Foot.

9. (*a*) *Round Wire.*—The resistance per foot of round wire shall be calculated from the nominal specific resistance and the cross-section of the material. The limits on resistance per foot shall be as follows:

No. 30 A. w. g. (0.0100 in.) and larger	±5 per cent
No. 31 to 40 A. w. g. (0.0089 to 0.0031 in.)	±8 per cent
No. 40 A. w. g. (0.0031 in.) and smaller	±10 per cent

(*b*) *Strip Material.*—The resistance per foot of strip material shall be calculated from the nominal specific resistance and the cross-section of the material. In order to compensate for error in calculated cross-section on ribbon with rounded edges, the calculated values arrived at by multiplying the nominal width by nominal thickness shall be corrected by multiplying by the factor indicated in the following table:

RATIO OF WIDTH TO THICKNESS	FACTOR
15 and under	0.94
Over 15	0.83

Resistance Increase with Temperature.

10. Temperature coefficient of resistance shall, after the wire has been slowly cooled from an annealing temperature, be measured in accordance with the Standard Method of Test for Change of Resistance with Temperature of Metallic Materials for Electrical Heating (A.S.T.M. Designation: B 70) of the American Society for Testing Materials.[2] The temperature coefficient of resistance shall be such as will bring the resistance within ± 20 per cent of the following:

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 869.

[2] *Ibid.*, p. 872.

TEMPERATURE	RESISTANCE, PER CENT
77° F. (25° C.)	100
500° F. (260° C.)	104.0
600° F. (315° C.)	104.8
800° F. (427° C.)	106.3
1000° F. (537° C.)	107.4
1200° F. (649° C.)	108.0
1400° F. (760° C.)	108.6
1600° F. (871° C.)	109.7

Durability. 11. (*a*) When it is desired to determine the durability of the material at high temperature, life tests shall be made in accordance with the Tentative Accelerated Life Test for Metallic Materials for Electrical Heating (A.S.T.M. Designation: B 76 – 29 T) of the American Society for Testing Materials.[1] Test results shall be reported as a percentage of a standard of comparison.

(*b*) The life or durability value shall be the average of at least three simultaneous determinations each, on the wire in question and on the standard. If any test result varies more than 10 per cent from the average of the three determinations, that group shall be discarded.

FINISH

Finish. 12. The material shall be as uniform and free from surface defects such as splits, kinks, laminations, scale, and other irregularities as the best commercial practice will permit. Finish shall be either bright annealed or oxidized, as specified.

PACKING AND MARKING

Packing. 13. (*a*) *Round Wire or Rod.*—Round wire or rod in sizes No. 16 A.w.g. or larger, shall be supplied in coils consisting of not more than two pieces per 40-lb. coil. Round wire sizes smaller than 16 gage shall be supplied in spools containing not more than two pieces and shall be spooled in accordance with the following requirements:

WEIGHT OF WIRE, LB.	SPOOL DIMENSIONS			
	DIAMETER OF FLANGE, IN.	TRAVERSE, IN.	DIAMETER OF HOLE, IN.	DIAMETER OF BARREL, IN.
1	2	3	$\frac{5}{8}$	$1\frac{1}{4}$
2	$2\frac{3}{4}$	3	$\frac{5}{8}$	$1\frac{1}{2}$
5	4	3	$\frac{5}{8}$	$1\frac{1}{2}$
10	6	3	$\frac{5}{8}$	$1\frac{3}{4}$
25	9	4	1	$3\frac{3}{4}$

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 613 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 208.

(*b*) *Ribbon.*—Ribbon over $\frac{1}{4}$ in. in width shall be supplied in coils containing not more than one piece, and shall be securely wrapped so as to avoid injuring the edges of the strips. Ribbon of $\frac{1}{4}$ in. in width or narrower shall be supplied on suitable spools containing not more than two pieces per spool.

14. Coils or spools shall be marked with the size and resistance per foot and a red tag or label shall be used to indicate this alloy. **Marking.**

TENTATIVE SPECIFICATIONS

FOR

ALUMINUM-BASE ALLOY DIE CASTINGS[1]

A.S.T.M. Designation: B 85 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover die castings die-cast from aluminum-base alloys. Seven alloy compositions are specified, designated alloys Nos. IV to IX, inclusive, and XII.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 2. The alloys shall conform to the requirements as to chemical composition given in Table I within the limits specified therein.

3. (*a*) It is understood that iron contributes to the hardness in all these alloys. While the use of steel or iron containers for the commercial manufacture of die castings unavoidably introduces some of this element into the alloy, it shall not exceed the percentages specified in Table I.

(*b*) Manganese and nickel are not regarded as harmful elements in these alloys up to the limits specified in Table I.

Sampling. 4. Samples for chemical analysis may be taken either by sawing, drilling, or milling a representative group of castings, and shall represent the average cross-section of the material. The castings and cutter shall be thoroughly cleaned and no lubricant shall be used during the operations.

Chemical Analysis. 5. Chemical analysis shall be made in accordance with the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (A.S.T.M. Designation: B 40 – 28 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. V. Faragher, Secretary of Committee B-6 on Die-Cast Metals and Alloys, Aluminum Co. of America, 2400 Oliver Building, Pittsburgh, Pa.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 782 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 157.

SOUNDNESS

Density. 6. No casting shall be acceptable which weighs less than a minimum agreed upon by the manufacturer and purchaser for the individual order.

WORKMANSHIP AND FINISH

Finish. 7. Castings shall be produced with smooth surfaces, free from cracks and disfiguring blemishes.

TABLE I.—CHEMICAL COMPOSITIONS OF ALUMINUM-BASE DIE-CASTING ALLOYS.

Alloy[a]	Desired Composition per cent				Permissible Variations in Alloying Elements, per cent				Other Elements, Maximum, per cent					
	Copper	Silicon	Nickel	Aluminum	Copper	Silicon	Nickel	Aluminum	Iron	Zinc	Manganese	Magnesium	Tin	Total, Other Impurities
No. IV..	...	5	....	95	0.6 max.	4.5 to 6.0	0.5 max.	balance	2.0	0.75	0.3	0.1	0.1	0.2
No. V...	...	12	....	88	0.6 max.	11 to 13	0.5 max.	balance	2.0	0.75	0.3	0.1	0.1	0.2
No. VI.	2	3	....	95	1.5 to 2.5	2.5 to 3.5	0.5 max.	balance	2.5	0.75	0.3	0.1	0.1	0.2
No. VII.	4	5	....	91	3.5 to 4.5	4.5 to 5.5	0.5 max.	balance	2.25	0.75	0.3	0.1	0.1	0.2
No. VIII	1.5	1	2.25	95.25	1 to 2	0.75 to 2	1.75to2.5	balance	2.5	0.75	0.3	0.1	0.1	0.2
No. IX..	4	1.75	4	90.25	3.5 to 4.5	1.0 to 2.5	3.5 to 4.5	balance	2.5	0.75	0.3	0.1	0.1	0.2
No. XII.	8	1.5	....	90.50	7.0 to 9.0	1.0 to 2.0	0.5 max.	balance	2.5	1.0	0.3	0.1	0.2	0.5

[a] The alloy designations correspond to numbers used in the investigation on aluminum-base die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys), the alloy numbers omitted correspond to alloy compositions which were investigated by the Committee, but which were not considered desirable of inclusion in these specifications. See *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 192 (1929).

Dimensions. 8. Dimensional tolerances shall be within the limits specified on the drawings describing the casting or castings on order, or shall be within the limits specified in the order.

REJECTION

Rejection. 9. Castings which show injurious defects subsequent to acceptance may be rejected. The manufacturer's liability shall be confined to replacing rejected castings without charge to the purchaser.

APPENDIX

The data in the following table do not constitute a part of these specifications. They will indicate to the purchaser the physical properties that may be expected of tension and impact test specimens when made in a die, the test specimens being cast in regular production routine and conforming to the chemical composition specified. It should be thoroughly understood that the following figures represent die-cast test specimens and not specimens cut from commercial die-cast parts. Rockwell hardness values have not been shown because they are considered too unreliable on die castings.

Alloy	Tension Tests on Round Specimens		Charpy Impact on Square Specimens, ft-lb.
	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent	
No. IV	29 000	3.5	4.5
No. V	33 000	1.5	2.0
No. VI	30 000	3.5	5.0
No. VII	32 000	2.0	2.5
No. VIII	29 000	4.0	4.5
No. IX	31 000	1.5	2.0
No. XII	33 000	1.0	1.5

TENTATIVE SPECIFICATIONS
FOR
ZINC-BASE ALLOY DIE CASTINGS[1]

A.S.T.M. Designation: B 86 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover commercial zinc-base alloy die castings.

MANUFACTURE

Process. 2. (*a*) The alloy may be made by any approved method.

(*b*) The casting shall be of uniform quality and no scrap shall be used other than the sprues, gates, rejected castings, etc., of this alloy which are produced in the manufacturer's own plant. The rejected castings used shall be free from finishes, solder, or inserts which may contaminate the alloy.

Base Metal. 3. The base metal for all alloys shall be slab zinc conforming to the requirements of the Standard Specifications for Slab Zinc (Spelter) (A.S.T.M. Designation: B 6) of the American Society for Testing Materials[2] except that the total impurities including lead, iron, tin, and cadmium shall not exceed 0.02 per cent.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 4. The alloy[3] shall conform to the following requirements as to chemical composition:

Copper, per cent	2.5 to 3.5
Aluminum, per cent	3.5 to 4.5
Magnesium, per cent	0.02 to 0.12
Iron, maximum, per cent	0.1
Lead, maximum, per cent	0.010

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. V. Faragher, Secretary of Committee B-6 on Die-Cast Metals and Alloys, Aluminum Co. of America, Pittsburgh, Pa.

By adoption of these specifications, the American Society for Testing Materials does not undertake to insure any one utilizing such specifications against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] 1930 Book of A.S.T.M. Standards, Part I, p. 582.

[3] This alloy composition is identical with Alloy No. XXI in the investigation on zinc-base die-casting alloys carried out under the jurisdiction of Committee B-6 on Die-Cast Metals and Alloys (formerly Subcommittee XV on Die-Cast Metals and Alloys of Committee B-2 on Non-Ferrous Metals and Alloys), see *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 318 (1930).

Cadmium, maximum, per cent	0.005
Tin, maximum, per cent	0.005
Total other impurities, per cent	0.02
Zinc, per cent	remainder

Sampling. 5. (*a*) The sample for chemical analysis may be taken either by sawing, drilling, or milling the casting or tension test specimen, and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

PHYSICAL PROPERTIES AND TESTS

Expansion. 6. The average expansion of any five or more castings when aged as described in Section 8 shall not exceed 0.0025 in. per inch. An expansion of 0.0025 in. will be allowable in any dimension less than 1 in.

7. (*a*) Unless specified in the order, acceptance of castings under these specifications shall not depend upon the physical properties as determined by tension or impact test specimens.

(*b*) When specified, the alloy shall conform to the following requirements as to physical properties:

	MINIMUM AVERAGE OF FIVE SPECIMENS	MINIMUM OF INDIVIDUAL SPECIMENS
Tensile Strength, lb. per sq. in.	44 000	35 000
Elongation in 2 in., per cent	2.0	0.5
Charpy Impact value, ft-lb	6.0	4.0

Aging. 8. (*a*) The alloy shall conform to the following requirements as to physical properties after being exposed to water vapor at 95° C. for 10 days.

	AVERAGE OF FIVE SPECIMENS
Tensile Strength, minimum, lb. per sq. in.	30 000
Elongation in 2 in., minimum, per cent	0.5
Impact Charpy, minimum, ft-lb	0.75
Expansion per inch, maximum, in.	0.0025

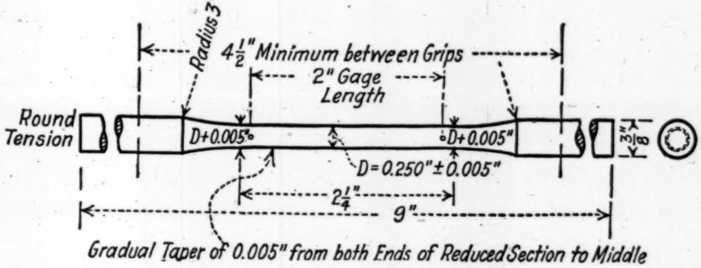
(*b*) The humidity cabinet shall contain no wood or organic matter and the specimens shall be supported only by glass, porcelain, zinc, or zinc-coated metal.

Test Specimens. 9. (*a*) The test specimens shall be die cast according to the dimensions shown in Figs. 1 and 2 and shall be tested without machining.

No ejector pins shall be used on reduced sections. Specimens shall be removed from dies as soon as cast and cooled in still air with gates attached.

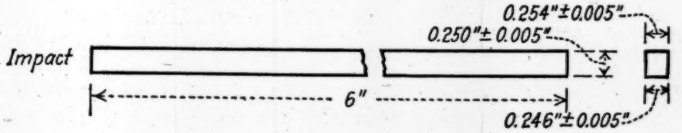
(*b*) Impact test specimens shall be made by cutting the 6-in. bar into two pieces 3 in. in length. The anvil of the testing machine shall have a 40-mm. span. The parting line of the test specimen shall be placed against the anvil.

Defective Bars. (*c*) In case any of the test specimens contain a flaw or flaws which results in failure of the alloy to meet the specifications, the manufacturer and purchaser shall agree upon the selection of specimens for retests, or the defective bars shall be disregarded.



Radius 3"
4½" Minimum between Grips
2" Gage Length
Round Tension
D+0.005"
D+0.005"
⅜"
D=0.250"±0.005"
2¼"
9"
Gradual Taper of 0.005" from both Ends of Reduced Section to Middle

FIG. 1.—Round Tension Test Specimen.



0.254"±0.005"
0.250"± 0.005"
Impact
6"
0.246"±0.005"

FIG 2.—Charpy Impact Test Specimen.

Number of Tests. 10. Five of each type of test specimen shall be tested.

Soundness. 11. Heavy section die castings are subject to spongy centers. The extent of this spongyness if objectionable shall be mutually agreed upon by the manufacturer and purchaser for each individual casting.

WORKMANSHIP AND FINISH

Finish. 12. The die casting shall be produced free from cracks and other disfiguring blemishes.

REJECTION

Rejection. 13. Die castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected the manufacturer's responsibility shall be limited to replacing rejected parts without charge to the purchaser.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF SILVER SOLDERS[1]

A.S.T.M. Designation: B 81 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

GENERAL CONSIDERATIONS

In the analysis of silver solder the usual determinations are silver, copper, cadmium and zinc. In routine analysis, however, it is customary to take zinc by difference.

Methods are provided for the determination of lead, tin, iron and nickel as impurities, starting with a separate 5-g. sample. The methods for determination of impurities are based on the consideration that any of these will not exceed a few tenths of a per cent in amount; in case it is necessary to determine larger quantities, the size of the sample may be reduced accordingly.

In the scheme as outlined below, the procedure for the determination of main constituents is kept separate from the determination of impurities, in the belief that such an arrangement will provide continuous procedures convenient for general use.

DETERMINATION OF SILVER

METHOD

Weigh 1 g. of the sample into a 250-cc. beaker, add 20 cc. of HNO_3 (1:4), cover, gently warm until solution is complete, and boil to expel NO_2 fumes; dilute to a volume of 175 cc. with distilled water and heat to boiling. Add drop-by-drop, from a pipette, a dilute solution of HCl (3:100) (1 cc. of this solution should precipitate about 0.038 g. of silver) until precipitation is complete. It is important to avoid a large excess of the precipitant. When the solution has become cold and the precipitate has settled, test the clear solution with a few drops of the dilute HCl to determine whether or not precipitation is complete. Filter on a weighed porcelain Gooch crucible, washing the precipitate several times with a cold dilute solution of HNO_3 (1:200) and once with cold distilled water. Save the filtrate for the determination of copper. Place the Gooch crucible inside a porcelain crucible, dry and heat the latter to dull red in the oxidizing flame of a Tirrill burner, cool and weigh as AgCl. Calculate to Ag.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, 7016 Euclid Ave., Cleveland, Ohio.

NOTES

1. If tin is present, as shown by a precipitate of metastannic acid when dissolving in nitric acid, it should be filtered off as directed under Determination of Tin before proceeding with the determination of silver. It is particularly important to observe the precautions regarding contamination by chlorides, noted under Determination of Tin.[1]

2. AgCl melts at 451° C. and, if heated too long at too high a temperature, low results are obtained. The final ignition of this precipitate should not be carried beyond the point of incipient fusion.

DETERMINATION OF SILVER
BY THE
COMBINATION ASSAY METHOD

SOLUTIONS REQUIRED

Sodium Chloride Solution.—Dissolve 107 g. of NaCl in 2000 cc. of distilled water. One cubic centimeter of this solution will precipitate 100 mg. of Ag.

METHOD

Weigh out an amount of sample which will be equivalent to 300 to 500 mg. of silver. Dissolve in dilute HNO_3 (1:4), allowing 20 cc. of dilute acid for each gram of sample, in a 400 cc. beaker. Cover and then boil to remove NO_2 fumes and dilute to 350 cc. with hot H_2O. Precipitate AgCl in the hot solution with NaCl solution. Avoid an excess. As long as some Ag remains unprecipitated, the solution will clear rapidly on stirring; towards the end the cloudiness will persist for some time. Allow to settle (over night for best results.)

Test with a drop of sodium chloride solution. If clear, filter through a double 11-cm. closely-woven paper. Wash well with hot water to aid in removing copper. Add 5 g. of test lead to precipitate in the paper. Place in a 2½ in. scorifier which has been lined with a sheet of lead weighing approximately 10 g. Incinerate in an oven or muffle. Cover ash with 20 g. of test lead, add 1 g. of a mixture composed of equal parts of silica and borax glass. Scorify to about a 14 to 16-g. button, pour in mold, clean off slag, hammer into a cube and cupel in a moderately hot muffle, no attempt being made to feather. When cupellation is finished, set a hot cupel inverter, over the one holding the head and withdraw both cupels from the furnace. Clean and weigh button as Ag. Corrections are made as determined by running proofs of approximately the same composition as the solder being analyzed.

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[1] See p. 729.

NOTE

All lead should be bismuth and silver free.

DETERMINATION OF COPPER
BY THE
ELECTROLYTIC METHOD

APPARATUS FOR ELECTROLYSIS

See the Determination of Copper by Electrolytic Method in the Standard Method of Chemical Analysis of Manganese Bronze (A.S.T.M. Designation: B 27) of the American Society for Testing Materials.[1]

METHOD

Transfer the filtrate from AgCl (Determination of Silver) to a 400-cc. beaker, add 5 cc. of H_2SO_4 (sp. gr. 1.84) and evaporate to fumes, cool, dilute to a volume of 50 cc. with distilled water, and boil. Add 2 cc. of HNO_3 (sp. gr. 1.42), transfer to a 200-cc. lipless beaker, dilute to a volume of 100 cc. with cold distilled water, and electrolyze for copper, using stationary electrodes and a current of 1.0 ampere. When the solution is colorless, wash down cover glasses, electrodes and sides of beaker, raising the level of the liquid slightly, and continue the electrolysis about 15 minutes, noting whether or not copper is deposited on the newly exposed surface of the platinum. If no copper appears, remove the cathode quickly, washing it with distilled water, and catching all washings in the beaker containing the electrolyte. Save the electrolyte for the determination of cadmium and zinc. Dip the cathode in two successive baths of alcohol, shake off the excess alcohol, and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually as the alcohol burns. Weigh metallic copper.

NOTE

If denatured alcohol is used for drying cathode with copper deposits, it should not show any weighable residue on evaporation to dryness. Alcohol denatured only by the addition of methyl alcohol is suitable for this purpose.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 813.

DETERMINATION OF CADMIUM
BY THE
ELECTROLYTIC METHOD

SOLUTIONS REQUIRED

Potassium Hydroxide (Note 1).—Dissolve 20 g. of KOH, c.p., in 200 cc. of distilled water.

Potassium Cyanide (Note 2).—Dissolve 20 g. of KCN, c.p., in 200 cc. of distilled water.

METHOD

Transfer the electrolyte from the determination of copper to a 600-cc. beaker and boil to expel dissolved gases. Make slightly alkaline with NH_4OH (1:1), and then just neutral with H_2SO_4 (1:4); finally add 25 cc. of H_2SO_4 (1:4) in excess, dilute to a volume of 300 cc. with distilled water, bring to a boil, and pass H_2S for one hour (Note 3). Allow to stand until the precipitate has settled and filter off impure CdS (Note 4) on a loose-bottom Gooch crucible. Remove the precipitate by punching out the bottom into a tall 200-cc. beaker, washing and wiping off the sides of the crucible with a little asbestos pulp. Add 60 cc. of H_2SO_4 (1:5) and boil for 30 minutes (Note 5). Filter, wash, and dilute to 300 cc., add about 5 g. of NH_4Cl, and precipitate with H_2S gas as before (Note 6). Repeat, making a third precipitation if the amount of cadmium present is large (Note 5). Save combined filtrates from CdS for the determination of zinc. Dissolve the final precipitate of CdS in 25 cc. hot HCl (1:3), boil to remove H_2S, add a few drops of HNO_3 (sp.gr. 1.42) near the end, and filter off the separated sulfur. Transfer the solution to a 200-cc. tall form lipless beaker, add a drop or two of phenolphthalein and then KOH solution until a permanent red color is obtained. Add KCN solution with constant stirring until the precipitate $Cd(OH)_2$ is completely dissolved (Note 8). Dilute to 150 cc. and electrolyze with a current of 5 amperes for two hours (Note 9). Test for completeness of deposition by washing the watch glasses and sides of the beaker to increase the depth of the solution. Continue the electrolysis for 20 minutes and, if the newly exposed portion of the cathode is still bright, remove the beaker with the electrolyte and wash the electrode three times with distilled water and twice with ethyl alcohol (95 per cent). Dry the cathode at 100° C., cool and weigh. The increase is metallic cadmium.

NOTES

1. Pure NaOH may be used in place of KOH.

2. Pure NaCN may be used in place of KCN.

3. It is occasionally necessary to add a drop or two of ammonia water to the solution to start the precipitation of CdS.

4. All the cadmium will be precipitated as sulfide together with some ZnS. The major portion of the zinc will remain in solution.

5. In case of high cadmium content, more acid may be required. The final acidity should not exceed 10 cc. of H_2SO_4 (sp. gr. 1.84) in a volume of 300 cc.

6. The second precipitation should give practically pure CdS.

7. A third precipitation will remove any uncertainty as to the completeness of the separation of cadmium from zinc.

8. Avoid using an excess of KCN.

9. The test for completeness of deposition may be made after one hour when the quantity present is not large.

DETERMINATION OF CADMIUM
BY THE
GRAVIMETRIC METHOD

See Determination of Cadmium by the Electrolytic Method.[1]

METHOD

Dissolve the final precipitate of CdS with 25 cc. of hot HCl (1:3) into a weighed platinum dish (Note 1), add 10 cc. of H_2SO_4 (1:1), and evaporate the solution until copious fumes are evolved (Note 2). Remove the excess of H_2SO_4 by heating the dish cautiously, and finally heat to between 500 and 600° C. Cool and weigh as $CdSO_4$.

NOTES

1. A crucible may also be used if the volumes are kept small or evaporated before transferring to the crucible.

2. On evaporating to fumes, darkening of the solution may occur from filter paper shreds. This may be destroyed by diluting slightly with water and adding 5 cc. of HNO_3 (sp. gr. 1.42) and again evaporating to fumes. It is not advisable to add HNO_3 unless it is certain that all HCl has been expelled.

DETERMINATION OF ZINC
BY THE
VOLUMETRIC METHOD

SOLUTIONS REQUIRED

Potassium Ferrocyanide.—Dissolve 34.8 g. of $K_4Fe(CN)_6$ in 1000 cc. of distilled water and age this solution for at least 90 days. If necessary, add 0.3 g. of $K_3Fe(CN)_6$ to the solution (Note 1). Standardize against c.p. zinc as follows:

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[1] See p. 725.

Weigh 0.3 to 0.35 g. of c.p. zinc into a tall 400-cc. beaker, add about 75 cc. of water and 13 cc. of HCl (sp. gr. 1.20). Cover and when in complete solution boil for about 5 minutes. Cool, add 13 cc. of NH_4OH (sp. gr. 0.90), neutralize with HCl (sp. gr. 1.20), and add an excess of 2.5 cc. Dilute to 250 cc., heat to boiling, and titrate immediately with the potassium ferrocyanide solution as described under the method below. Calculate the factor of the $K_4Fe(CN)_6$ solution as follows:

$$\text{Factor of } K_4Fe(CN)_6 \text{ solution} = \frac{B}{A}$$

where A = the cubic centimeters of $K_4Fe(CN)_6$ solution required for the c.p. zinc; and

B = the weight of the c.p. zinc

Ferrous Sulfate.—Weigh 1.25 g. of $FeSO_4 \cdot 7H_2O$ into a tall 150-cc. beaker and add about 3 g. of granular aluminum. Fill the beaker about half full with water and add about 0.15 cc. of HCl (sp. gr. 1.20). Heat to boiling and boil until the solution clears. Cool, transfer to a 250-cc. measuring flask, and dilute to the mark. Mix well before using.

Sulfuric Acid (1:1).—Mix cautiously 100 cc. of H_2SO_4 (sp. gr. 1.84) with 100 cc. of cold distilled water.

METHOD

(Refer to Determination of Cadmium)

Add 10 cc. of H_2SO_4 (1:1) to the combined filtrates from the cadmium determination and evaporate to dryness. Take up with 100 cc. of water and 10 cc. of HCl (sp. gr. 1.20) and heat until all is in solution. Transfer the solution to a 400-cc. beaker, neutralize (Note 2) with NH_4OH (sp. gr. 0.90), and add exactly 2.5 cc. of HCl (sp. gr. 1.20). Dilute to 250 cc., heat to boiling, and titrate immediately with the potassium ferrocyanide solution as follows:

Transfer about one-half of the solution to be titrated into a 150-cc. beaker. Add 0.5 cc. of the ferrous sulfate solution to the portion remaining in the original beaker and run the $K_4Fe\ (CN)_6$ solution into this portion with constant stirring until the blue color changes to pea-green, then add an excess of 3 cc. of $K_4Fe\ (CN)_6$ (Note 3). Pour the solution from the 150-cc. beaker into the solution in the 400 cc. beaker, retaining from 2 to 3 cc., and titrate until the end point is passed by 2 to 3 drops. Wash the remaining solution from the side beaker into the main portion. Add 0.05 cc. of $K_4Fe(CN)_6$ solution at a time until the end point is reached. The end point is a change from blue to pea-green (Note 4).

Calculate the percentage of zinc as follows:

$$\text{Zinc, per cent} = \frac{A \times C \times 100}{\text{Weight of sample}}$$

where A = the cubic centimeters of $K_4Fe\ (CN)_6$ solution required for the sample; and

C = the factor of the $K_4Fe\ (CN)_6$ solution (grams of zinc per cubic centimeter).

NOTES

1. The purpose of aging is to remove any oxidizing agents by the reducing action of the $K_4Fe(CN)_6$. A small amount of $K_3Fe(CN)_6$ is formed. If this is sufficient to give the proper blue color with the ferrous iron in the standardization, no more need be added.

2. Use litmus paper as the indicator.

3. The titration is carried out in this manner in order to insure proper composition of the precipitate.

4. The end point is best observed by looking down through the solution. The blue color in the solution is due to Turnbull's blue formed by the interaction of ferrous iron with $K_3Fe(CN)_6$. This ferrous ferricyanide is stable until the $K_4\ Fe(CN)_6$ is present in excess when it forms the ferrous ferrocyanide which is colorless.

DETERMINATION OF ZINC
BY THE
ZINC OXIDE METHOD

METHOD

Evaporate the combined filtrates from CdS to a volume of about 100 cc. Make the solution just alkaline with NH_4OH and add 30 cc. of formic acid (sp. gr. 1.2) for every 200 cc. of final volume. Heat nearly to boiling, and pass in a rapid stream of H_2S for 15 minutes. Filter and wash with hot 2-per-cent formic acid solution saturated with H_2S. Dissolve the ZnS from the filter into the original beaker with 50 cc. of hot HCl (1:10) washing thoroughly with hot water. Boil to expel H_2S. Make just alkaline with ammonia, then add 20 cc. of formic acid (sp. gr. 1.2) and dilute to 200 cc. with distilled water. Heat to boiling and pass H_2S for 15 minutes. Filter and wash with formic acid wash water. To avoid creeping of the precipitate do not fill the paper too near to its top and do not wet the funnel above the paper. Ignite the paper and precipitate under good oxidizing conditions in a weighed porcelain or vitreosil crucible, raising the temperature gradually to a dull red heat and finishing with a moderate red. Cool and weigh as ZnO.

DETERMINATION OF TIN

METHOD

Dissolve a separate 5-g. sample with 100 cc. of HNO_3 (1:4) in a 400-cc. beaker. Boil to expel NO_2 fumes, and dilute to a volume of 250 cc. with boiling distilled water. Allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on double 7-cm. ashless papers, being careful to keep the solution hot throughout the process of filtration, washing with boiling hot water. Save the filtrate for the determination of lead. Ignite the paper and precipitate under good oxidizing conditions in a weighed porcelain crucible, and weigh as SnO_2.

NOTE

Every precaution must be taken to avoid contamination by chlorides from any source, in order to prevent the precipitation of AgCl during the determination of tin. All distilled water must be free from chlorides, beakers and apparatus must be carefully rinsed before using, and all chloride fumes must be avoided.

DETERMINATION OF LEAD

SOLUTIONS REQUIRED

"*Lead Acid.*"—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 1800 cc. of distilled water. Dissolve 1 g. of lead acetate, c.p., in 300 cc. of distilled water and add this to the hot solution, stirring meanwhile. Let stand for at least 24 hours and syphon through a thick asbestos filter.

Dilute Alcohol for Washing.—Mix equal parts of denatured alcohol and distilled water.

METHOD

Heat the filtrate from the metastannic acid to boiling, and precipitate silver with dilute HCl as in the Determination of Silver,[1] avoiding a large excess of the precipitant. When the solution has become cold and the precipitate has settled, test the clear solution with a few drops of the dilute HCl to determine whether or not precipitation is complete. Filter on a closely-woven paper, washing with cold dilute HNO_3 (1:200). Add 80 cc. of "lead acid" and evaporate to fumes. To insure complete removal of chlorides, cool, add a few cubic centimeters of H_2O and fume again. Cool, add 70 cc. of distilled water to dissolve the salts and to make the acid concentration the same as in "lead acid." Heat to boiling, and allow to cool and settle for 5 hours, or overnight if convenient. Filter on a weighed porcelain Gooch crucible and wash with "lead acid." Remove the filtrate and save for the determination of iron. Continue washing the precipitate with dilute alcohol, set the Gooch crucible inside a porcelain crucible, dry and ignite for 5 minutes at the full heat of a Tirrill burner, cool and weigh as $PbSO_4$.

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[1] See p. 722.

NOTE

In order to avoid "spitting" during evaporation with "lead acid" it is suggested to heat over a burner, holding the beaker with a pair of tongs and twirling as the evaporation is carried on.

DETERMINATION OF IRON

SOLUTIONS REQUIRED

Dilute Sulfuric Acid Solution for Reductor.—Mix 50 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water.

Standard Potassium Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. of H_2O and allow to stand for several days in a glass-stoppered bottle in a dark closet. Filter the solution through prepared asbestos and standardize against 0.1000-g. portions of pure sodium oxalate. Each cubic centimeter is equivalent to approximately 0.00177 g. of iron.

METHOD

To the filtrate from the $PbSO_4$ add 5 cc. of HNO_3 (sp. gr. 1.42) and remove copper by electrolysis. To the electrolyte add 5 g. of NH_4Cl, and 2 to 3 cc. of H_2O_2 or HNO_3 (sp. gr. 1.42), and boil to oxidize iron. Make ammoniacal, adding sufficient NH_4OH to dissolve any basic salts, and boil. Filter and wash with hot water. Dissolve the precipitate through the filter paper with hot dilute HCl and reprecipitate iron with ammonia. Filter and wash with hot water. Combine and save filtrates for the determination of nickel. Dissolve the precipitate through the filter with 100 cc. of hot dilute H_2SO_4, for reductor. Add a few drops of concentrated solution of

$KMnO_4$ until a distinct pink color persists, boil, cool, and pass the solution through the reductor. Wash the beaker and reductor with 150 cc. of dilute H_2SO_4 solution for reductor and then with 100 cc. of distilled water. Titrate with standard $KMnO_4$ solution.

NOTES

1. Results of titration should be checked with a blank determination made on corresponding amounts of solutions used.

2. A small quantity of liquid should always be left in the reductor funnel and air should never be allowed to enter the reductor.

3. For further details of the use of reductor see the "Chemical Analysis of Iron" by A. A. Blair, "Quantitative Chemical Analysis" by H. P. Talbot, or "Applied Inorganic Analysis" by Hillebrand and Lundell.

DETERMINATION OF NICKEL

SOLUTIONS REQUIRED

Dimethylglyoxime Solution.—Dissolve 5 g. of dimethylglyoxime in 500 cc. of ethyl alcohol and filter before using.

METHOD

Evaporate the combined filtrates from the precipitation of iron to a convenient volume, and make barely acid with HCl (sp. gr. 1.20). Heat nearly to boiling, and add 5 cc. of dimethylglyoxime solution for each 0.1 g. or fraction of nickel present and then NH_4OH in slight excess. Let stand at least 30 minutes on the steam bath. Filter and wash with dilute ammonia solution (1:100). For accurate work, the precipitate should be dissolved in hot HCl (1:1) and reprecipitated as before. Filter on a weighed Gooch crucible, wash with hot water, dry at 110 to 120° C. for about 2 hours and weigh as the glyoxime salt which contains 20.31 per cent nickel. If it is preferred, instead of weighing the glyoxime salt, the nickel can be determined electrolytically as follows: Dissolve the red precipitate of nickel glyoxime in hot HCl (1:1), add 10 cc. of H_2SO_4 (1:1) and evaporate to strong fumes. Dilute, neutralize with NH_4OH (sp. gr. 0.90), and add 20 cc. in excess. The final volume should be about 150 cc. Electrolyze with a current density overnight of 0.3 amperes per square decimeter (2.7 amperes per sq. ft.). Test the solution for completeness of deposition by removing 1 cc. to a porcelain test plate, and adding fresh H_2S water. Remove the cathode, wash with water, and dry with alcohol as in the Determination of Copper by the Electrolytic Method.[1] Weigh the deposit as metallic nickel.

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[1] See p. 724.

TENTATIVE METHOD OF TEST FOR DETERMINING THE TEMPERATURE-RESISTANCE CONSTANTS OF RESISTANCE ALLOYS[1]

A.S.T.M. Designation: B 84 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. This method provides for determining the change of resistance with temperature of wires of the manganin and constantan types (note) and for computing the constants of the resistance-temperature equation. It is applicable in the temperature range of 0 to 80° C. and is suitable for wires to be used in precision electrical apparatus.

NOTE.—These alloys are of the type having compositions similar to 84 per cent copper, 12 per cent manganese, and 4 per cent nickel; and 55 per cent copper, 45 per cent nickel, respectively.

TEST SPECIMEN

Sampling. 2. One test specimen shall be taken from each continuous length of finished material.

Test Specimen. 3. (*a*) The test specimen shall be at least 5 meters in length.

(*b*) If the wire is insulated, it may be wound in a circular, open coil not less than 5 cm. in diameter.

(*c*) If the wire is not insulated, it may be wound on an insulating form of a type that will not introduce strains in the wire when subjected to temperature changes.

(*d*) The tension used in winding shall be no more than sufficient to produce a neat coil of insulated wire or to prevent the touching of adjacent turns when bare wire is wound on an insulating form.

Terminals. 4. (*a*) A terminal of copper wire, 5 to 10 cm. in length, shall be attached to each end of the specimen, as an integral part thereof, by brazing or soldering. The resistance of the copper terminals shall be less than 0.02 per cent of the resistance of the specimen unless a method of measuring the resistance is used which eliminates the effect of the terminal resistance.

(*b*) If the resistance of the specimen is less than 100 ohms, each terminal shall consist of a double wire affixed to each end of the sample so that the specimen may be measured either as a three or four-terminal conductor.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, Driver-Harris Co., Harrison, N. J.

(*c*) In coils made of fine wire where there is not sufficient rigidity in the coil itself to furnish a satisfactory support for the terminals, short lengths of thin glass or ceramic rods may be bound across the coil to act as struts and furnish an anchorage for the terminals.

Preliminary Treatment.

5. The finished specimen shall be subjected to a temperature of 140° C. ± 10° C. continuously for a period of 48 hours in order to stabilize the resistance of the wire. The measured characteristics of the specimen after baking shall be considered as the true temperature-resistance characteristics of the wire.

APPARATUS AND MEASUREMENTS

Apparatus.

6. The apparatus for making the test shall consist of one or more baths for maintaining the specimen at the desired temperatures, a device for measuring the bath temperatures, and a suitable apparatus for measuring the resistance of the specimen.

Baths.

7. (*a*) A bath of chemically neutral oil shall be used which shall be provided with means for effective stirring or circulation, and be so constructed that the test specimen can be held at a uniform and constant temperature at the desired values.

(*b*) At any temperature between 0 and 40° C. the temperature difference between the parts of the bath occupied by the specimen and by the thermometer shall be not more than 0.1° C. and at temperatures between 40 and 80° C. this difference shall not exceed 0.2° C.

(*c*) The temperature of the oil adjacent to the test specimen shall be measured to an accuracy of 0.2° C. for temperatures up to 40° C. and to an accuracy of 0.3° C. for temperatures between 40 and 80° C.

Temperature Measurements.

8. A laboratory type mercurial thermometer or an appropriately constructed and calibrated resistance thermometer may be used for making the temperature measurements.

Resistance Measurements.

9. (*a*) The resistance of the specimen shall be measured by means of an apparatus capable of measuring the change in resistance of the specimen with an error not exceeding 0.001 per cent of the resistance of the specimen if the temperature range is 50° C. or more. If the temperature range is less than 50° C., the accuracy of the resistance measurements shall be correspondingly greater.

(*b*) The connections from the specimen to the measuring device shall be such that changes in the resistance of these connections due to changes in their temperature do not appreciably affect the measurement of the change in resistance of the specimen.

(*c*) The temperature of the measuring apparatus shall not change due to changes in room temperature by an amount sufficient to introduce appreciable errors in the measured values. With apparatus of good quality a change of 1° C. at room temperature is allowable.

(*d*) The test current shall not be of such a magnitude as to produce an appreciable change in resistance of the specimen or measuring apparatus due to the heating effect.

NOTE.—To determine experimentally that the nominal test current is not too large, the specimen may be immersed in the bath at a temperature where there is a relatively large change in resistance with temperature. The test current should be applied and maintained until the resistance of the specimen has become constant. The current should then be increased by 40 per cent and maintained at this value until the resistance has again become constant. If the change in resistance is greater than 0.001 per cent, the test current is too large and should be reduced until the foregoing limitations are reached.

(*e*) The measurements must be made in such a way that the effects of thermoelectromotive forces and parasitic currents are avoided. When these effects are small their influence on the final result may be made negligible either by reversing the battery current and taking the mean of the reversed readings or by keeping the galvanometer circuit closed and working to the galvanometer zero obtained with open battery circuit.

PROCEDURE

Procedure. 10. (*a*) The test specimen shall be connected in the measuring circuit and, including the terminals, shall be entirely submerged in the oil bath. The temperature of the oil bath shall be maintained constant at the highest temperature at which measurements are to be made. When the test specimen has attained a constant resistance, note the reading of the measuring device and the temperature of the bath.

(*b*) The temperature of the test specimen shall then be decreased to the next lower temperature either by cooling the oil and maintaining it constant at the lower temperature, or by removing the specimen to another bath maintained at the lower temperature. When the resistance of the specimen has become stationary, observations of resistance and temperature shall again be made.

(*c*) In this manner a series of temperature resistance change determinations shall be made for descending temperatures over the temperature range desired, measurements being taken at from 4 to 6° C. intervals between 15 and 35° C. and at intervals of approximately 15° C. outside this range.

(*d*) Tests shall be made at not less than four temperatures.

(*e*) The temperature of the measuring apparatus shall be noted at frequent intervals during the test of each specimen.

CALCULATIONS

Resistance Temperature Equation.

11. The results shall be expressed in terms of the constants in an equation of the form:

$$R_t = R_{25}\left[1 + \alpha(t - 25) + \beta(t - 25)^2\right]$$

where R_t = the resistance of the specimen at $t°$ C.;

R_{25} = the resistance of the specimen at the standard temperature of 25° C., and

α and β = the temperature-resistance constants of the material.

Calculation of Constants.

12. (*a*) The values of α, β and R_{25} may be determined by selecting the measured values of R_t at three well-separated temperatures, inserting the values of R_t and t in the above equation to form three equations, and solving simultaneously the three equations for R_{25}, α and β.

(*b*) When the measurements have not been made at exactly 25° C. or at other suitable temperatures, the computation may be simplified by plotting a curve from the observed values of resistance and temperature, from which curve the value R_{25} can be read directly. Two additional points may then be selected on the curve, preferably one, t_1, at least 5° C. below the reference temperature of 25° C., and a second temperature, t_2, near the highest temperature measured but satisfying the relation:

$$K(25 - t_1) = t_2 - 25 = K\Delta t$$

where K is, for ease of computation, generally taken as an integer.

NOTE.—*Example*: If t_1 is 10° C. below the reference temperature, then t_2 should be 10 or 20 or 30° C., etc., above the reference temperature for greatest ease of computation, so that $K = 1$ or 2 or 3, respectively.

If R_1 is the resistance at the temperature t_1 and R_2 is the resistance at the temperature t_2, then:

$$\alpha = \frac{(R_2 - R_{25}) - K^2(R_1 - R_{25})}{R_{25}K(K + 1)\Delta t}$$

$$\beta = \frac{K(R_1 - R_{25}) + (R_2 - R_{25})}{R_{25}K(K + 1)(\Delta t)^2}$$

If $K = 1$, this simplifies to:

$$\alpha = \frac{R_2 - R_1}{2R_{25}\Delta t}$$

$$\beta = \frac{R_1 + R_2 - 2R_{25}}{2R_{25}(\Delta t)^2}$$

If, instead of measuring the actual resistances at the different temperatures, the change in resistance relative to the resistance at 25° C. is measured, the above formulas take a slightly different form, as follows:

Let ΔR_1 represent the change in resistance in ohms per ohm in going from 25° C. to t_1 and ΔR_2 the similar change in going from 25°C. to t_2. That is:

$$\Delta R_1 = \frac{R_1 - R_{25}}{R_{25}} \quad \text{and} \quad \Delta R_2 = \frac{R_2 - R_{25}}{R_{25}}$$

then

$$\alpha = \frac{\Delta R_2 - K^2 \Delta R_1}{K(K+1)\Delta t}$$

$$\beta = \frac{K\Delta R_1 + \Delta R_2}{K(K+1)(\Delta t)^2}$$

If $K = 1$, this simplifies to:

$$\alpha = \frac{\Delta R_2 - \Delta R_1}{2\Delta t}$$

$$\beta = \frac{\Delta R_1 + \Delta R_2}{2(\Delta t)^2}$$

REPORT

Report. 13. The report shall include the following information:

(*a*) Description of material and its insulation;

(*b*) Identification of specimen;

(*c*) Length of wire in specimen and approximate resistance;

(*d*) Tabular list of resistances and temperatures in the order taken;

(*e*) Temperature of measuring apparatus at start and finish of test;

(*f*) Values of t and ΔR used in computing α and β;

(*g*) Values computed for the temperature-resistance constants α and β; and

(*h*) The temperature of the specimen at which the change of resistance with temperature is zero, if such occurs within the measured range.

Record. 14. The measurements shall be recorded on a data sheet similar to that shown in Table I.

TABLE I.—DATA AND COMPUTATION SHEET FOR RECORD OF TEST ON TEMPERATURE-RESISTANCE CHARACTERISTICS WITH AN ILLUSTRATIVE SET OF DATA.

RECORD OF TEST ON TEMPERATURE-RESISTANCE CHARACTERISTICS

MATERIAL. . Manganin, Specimen No. 1 Maker. . John Doe
SIZE: 0.010 in. Approximate Resistance of Specimen: 100 ohms
INSULATION: Double Silk. Length of Wire 11.4 meters

Order of Measurement	Temperature, deg. Cent.	Resistance,[a] ohms	$\Delta R_t \times 10^{-6} = \frac{R_t - R_{25}}{R_{25}} \times 10^{-6}$
1[b]	25	99.8743	......
2	80	99.7336	−1403
3	65	99.7936	−803
4	50	99.8391	−348
5	35	99.8671	−72
6	30	99.8717	−22
7	25	99.8739	0
8	20	99.8735	−4
9	15	99.8707	−32
10[b]	25	99.8739	

[a] If the method of measurement is such that ΔR_t is measured directly, this column may be omitted.

[b] Indicates stability only, not used in computation.

COMPUTATIONS

ORIGINAL

TEMPERATURE, DEG. CENT.	$\Delta R_t \times 10^{-6}$
25	0
15	−32
65	−803

$\Delta_t = 10$
$K = 4$
$\alpha = -1.46$
$\beta = -0.47$

SUPPLEMENTARY

TEMPERATURE, DEG. CENT.	$\Delta R_t \times 10^{-6}$
25	0
20	−4
80	−1407

$\Delta_t = 5$
$K = 11$
$\alpha = -1.40$
$\beta = -0.44$

Average $\alpha = -1.4 \times 10^{-6}$
Average $\beta = -0.45 \times 10^{-6}$

Temperature for which R is a maximum $= 25° - \frac{\alpha}{2\beta} = 23.4°$ C.

TENTATIVE SPECIFICATIONS
FOR
SAND FOR USE IN LIME PLASTER[1]

A.S.T.M. Designation: C 66 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927; Revised, 1931.

Definition. 1. Sand may be defined as follows:[2]

Sand.—The fine granular material (usually less than ¼ in. in diameter) resulting from the natural disintegration of rock, or from the crushing of friable sandstone rocks.

Note.—When used without a qualifying adjective, the term sand is generally understood to mean the product of the natural disintegration of siliceous or calcareous rock. Sand should be distinguished from screenings, gravel, etc. The size of particle and other physical characteristics should be taken care of in specifications. The fine material resulting from the crushing of blast-furnace slag is known as "slag sand."

General Requirements. 2. Sand for lime plaster shall consist of hard, strong, durable, uncoated, mineral or rock particles (as limited by the above definition), free from injurious amounts of saline, alkaline, organic, or other deleterious substances.

Grading. 3. Sand for lime plaster shall be uniformly graded from fine to coarse within the following limits:

Retained on a No. 4 (4760-micron) sieve	none
Retained on a No. 8 (2380-micron) sieve	not more than 10 per cent
Retained on a No. 30 (590-micron) sieve	not more than 80 per cent not less than 15 per cent
Retained on a No. 50 (297-micron) sieve	not more than 95 per cent not less than 70 per cent
Retained on a No. 100 (149-micron) sieve	not less than 95 per cent
Weight removed by decantation	not more than 5 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. V. Brumbaugh, Secretary of Committee C-7 on Lime, 927 Fifteenth St., N. W., Washington, D. C.

[2] As defined by Committee E-8 on Nomenclature and Definitions in the Standard Definition of the Term Sand (A.S.T.M. Designation: C 58) of the American Society for Testing Materials, see 1930 Book of A.S.T.M. Standards, Part II, p. 165.

Sieve Analyses.

4. The sieve analysis shall be made in accordance with the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41) of the American Society for Testing Materials.[1]

Decantation Test.

5. The decantation test shall be made in accordance with the Standard Method of Decantation Test for Sand and Other Fine Aggregates (A.S.T.M. Designation: D 136) of the American Society for Testing Materials.[2]

Organic Impurities.

6. Sand, when tested in accordance with the Standard Method of Test for Organic Impurities in Sands for Concrete (A.S.T.M. Designation: C 40) of the American Society for Testing Materials,[3] shall show a color not darker than the standard color, unless it is shown by adequate tests that the impurities causing the color are not harmful in plaster.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 155

[2] *Ibid.*, p. 618.

[3] *Ibid.*, p. 154.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM WALL BOARD[1]

A.S.T.M. Designation: C 36 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Definition. 1. Gypsum wall board is a gypsum plaster board designed to be used, without the addition of plaster, for walls, ceilings or partitions and affording a surface suitable to receive decoration.

MANUFACTURE

Composition. 2. Gypsum wall board shall consist of an incombustible core of gypsum, with or without fiber, but not exceeding 15 per cent fiber by weight, and surfaced with paper or other fibrous material firmly bonded to the core.

PROPERTIES AND TESTS

Flexural Strength. 3. When tested either face up or face down in accordance with Section 14, specimens taken from the gypsum wall board shall carry not less than the following loads without showing a breaking of the bond between the surfacing and the core:

Thickness, in.	Thickness, mm.	Load, lb., Knife Edges Across Fiber of Surfacing	Load, lb., Knife Edges Parallel to Fiber of Surfacing
¼	6.3	50	24
⅜	9.5	80	34
½	12.7	105	45

Sampling. 4. At least 1 per cent of the number of gypsum wall boards in a shipment, but not less than ten boards, shall be so selected as to be representative of the shipment. Twenty-five per cent of such selected boards, but not less than ten individual boards, shall constitute a sample for purposes of test. When a shipment consists of more than one car, or carrier load, a sample shall be taken from each car or carrier.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 211 W. Wacker Drive, Chicago, Ill.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Gypsum Wall Board (A.S.T.M. Designation: C 36 – 25), 1930 Book of A.S.T.M. Standards, Part II, p. 114.

DIMENSIONS, WEIGHTS AND PERMISSIBLE VARIATIONS

5. The nominal thickness of gypsum wall board shall be $\frac{1}{4}$ in. (6.3 mm.), $\frac{3}{8}$ in. (9.5 mm.), or $\frac{1}{2}$ in. (12.7 mm.), with permissible variations in the nominal thickness of $\pm\frac{1}{64}$ in. (0.4 mm.), and with permissible local variations of $\pm\frac{1}{32}$ in. (0.8 mm.) from the nominal thickness. **Thickness.**

6. (*a*) The nominal width of gypsum wall board shall be 32 in. (810 mm.), 36 in. (910 mm.) or 48 in. (1220 mm.), with a permissible variation of $\frac{3}{32}$ in. (2 mm.) under the specified width. **Width.**

(*b*) Beveled edge wall boards may have widths $\frac{1}{4}$ in. (6.3 mm.) less than those specified in Paragraph (*a*) with the same permissible variation.

7. The nominal length of gypsum wall board shall be from 4 ft. (1.22 meters) to 12 ft. (3.66 meters), inclusive, with permissible variations of $\pm\frac{1}{4}$ in. (6.3 mm.) from the specified length. **Length.**

8. The weight of gypsum wall board per 1000 sq. ft. shall conform to the following requirements: **Weight.**

Thickness, in.	Thickness, mm.	Weight per 1000 sq. ft. Minimum, lb.	Minimum, kg.	Maximum, lb.	Maximum, kg.
$\frac{1}{4}$	6.3	900	408	1500	680
$\frac{3}{8}$	9.5	1350	612	2000	905
$\frac{1}{2}$	12.7	1800	816	3000	1361

FINISH

9. The face of gypsum wall board shall be true and free from imperfections that would render the wall board unfit for use with or without decoration. The edges and ends shall be straight and solid. The corners shall be square with a permissible variation of $\frac{1}{8}$ in. (3.2 mm.) in the full width of the board. **Finish.**

PACKING AND MARKING

10. Shipments of gypsum wall board shall conform to the following requirements: **Packing and Marking.**

(*a*) They shall be shipped so as to be kept dry and free from moisture.

(*b*) When shipped for resale, the following information shall be shown upon each board or package:

Name of manufacturer;
Brand.

INSPECTION AND REJECTION

Inspection. 11. Inspection may be made either at the point of shipment, or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 12. Any rejections shall be based upon failure to conform to the requirements of these specifications and shall be reported within ten working days from the receipt of the shipment by the consignee. The notice of rejection shall contain a specific statement of the respects in which the boards have failed to conform to the requirements of these specifications.

Rehearing. 13. Claims for rehearing shall be valid only if made within 20 working days from the receipt of notice of specific cause for rejection.

METHOD OF TESTING

Flexural Strength Test. 14. (*a*) *Test Specimens.*—Test specimens for the flexural strength test shall be taken from not less than ten gypsum boards. The test specimens shall be 12 in. (300 mm.) in width and approximately 16 in. (410 mm.) in length. The specimens shall be weighed to within 0.5 g. and then stored at a temperature of from 60 to 85° F. in an atmosphere of 25 to 50-per-cent relative humidity. The specimens shall be weighed once a day until the weight has become constant to within 0.1 per cent.

(*b*) *Procedure.*—The test specimen shall be centrally supported on fixed parallel bearings spaced 14 in. (350 mm.) between centers and the load-applying block brought in contact with the upper surface of the specimen midway between the supports. All bearings and load surfaces shall be true, shall engage the full width of the test specimen, and shall be rounded to a radius of $\frac{1}{8}$ in. (3.2 mm.). The test load shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate.

(*c*) *Report.*—Flexural strength test results shall be reported with the load applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM LATH[1]

A.S.T.M. Designation: C 37 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

1. Gypsum lath is a gypsum plaster board designed to be used as a base for the reception of gypsum plaster. **Definition.**

MANUFACTURE

2. Gypsum lath shall consist of an incombustible core of gypsum, with or without fiber, but not exceeding 15 per cent fiber by weight and surfaced with paper or other fibrous material firmly bonded to the core. **Composition.**

PROPERTIES AND TESTS

3. When tested either face up or face down in accordance with Section 14, specimens taken from the gypsum lath shall carry not less than the following loads without showing a breaking of the bond between the surfacing and the core: **Flexural Strength.**

Thickness, in.	Thickness, mm.	Load, lb. Knife Edges Across Fiber of Surfacing	Load, lb. Knife Edges Parallel to Fiber of Surfacing
$\frac{1}{4}$	6.3	40	16
$\frac{3}{8}$	9.5	60	27
$\frac{1}{2}$	12.7	100	40

4. At least 1 per cent of the number of gypsum laths in a shipment, but not less than ten laths, shall be so selected as to be representative of the shipment. Twenty-five per cent of such selected laths, but not less than ten individual laths, shall constitute a sample for purposes **Sampling.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 211 W. Wacker Drive, Chicago, Ill.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Gypsum Plaster Board (A.S.T.M. Designation: C 37 – 30), 1930 Book of A.S.T.M. Standards, Part II, p. 117.

of test. When a shipment consists of more than one car or carrier load, a sample shall be taken from each car or carrier.

DIMENSIONS, WEIGHTS AND PERMISSIBLE VARIATIONS

Thickness. 5. The nominal thickness of gypsum lath shall be $\frac{1}{4}$ in. (6.3 mm.), $\frac{3}{8}$ in. (9.5 mm.) or $\frac{1}{2}$ in. (12.7 mm.), with permissible variations in the nominal thickness of $\pm\frac{1}{32}$ in. (0.8 mm.) and with permissible local variations of $\pm\frac{1}{16}$ in. (1.6 mm.) from the nominal thickness.

Width. 6. The nominal width of gypsum lath shall be 16 in. (406.4 mm.), 24 in. (610 mm.) or 32 in. (810 mm.), with permissible variations of $\frac{1}{4}$ in. (6.3 mm.) under, and $\frac{1}{8}$ in. (3.2 mm.) over the specified width.

Length. 7. The nominal length of gypsum lath shall be 32 in. (810 mm.), 36 in. (910 mm.) or 48 in. (1220 mm.), with permissible variations of $\frac{1}{4}$ in. (6.3 mm.) under, and $\frac{1}{8}$ in. (3.2 mm.) over the specified length.

Weight. 8. The weight of gypsum lath per 1000 sq. ft. shall conform to the following requirements:

Thickness,		Weight per 1000 sq. ft.			
		Minimum,		Maximum,	
in.	mm.	lb.	kg.	lb.	kg.
$\frac{1}{4}$	6.3	900	408	1500	680
$\frac{3}{8}$	9.5	1350	612	2000	907
$\frac{1}{2}$	12.7	1800	816	3000	1361

FINISH

Finish. 9. The surfaces of gypsum lath shall be such that they will readily receive and retain gypsum plaster. The edges and ends shall be straight and solid. The corners shall be square with a permissible variation of $\frac{1}{4}$ in. (6.3 mm.) in the full width of the lath. Gypsum laths shall be free from cracks and imperfections that will render them unfit for use.

Note.—Gypsum laths that have their corners burred or broken shall be considered acceptable, provided that the broken portion is not more than 1 in. (25.4 mm.) along either dimension.

PACKING AND MARKING

Packing and Marking. 10. Shipments of gypsum lath shall conform to the following requirements:

(*a*) They shall be shipped so as to be kept dry and free from moisture.

(*b*) When shipped for resale, the following information shall be shown upon each lath or package:

Name of manufacturer;
Brand.

INSPECTION AND REJECTION

Inspection. 11. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 12. Any rejection shall be based upon failure to conform to the requirements of these specifications; and shall be reported within ten working days from receipt of the shipment by the consignee. The notice of rejection shall contain a specific statement of the respects in which the laths have failed to conform to the requirements of these specifications.

Rehearing. 13. Claims for rehearing shall be valid only if made within 20 working days from the receipt of notice of specific cause for rejection.

METHOD OF TESTING

Flexural Strength Test. 14. (*a*) *Test Specimens.*—Test specimens for the flexural strength test shall be taken from not less than ten gypsum laths. The test specimens shall be 12 in. (300 mm.) in width and approximately 16 in. (410 mm.) in length. The specimens shall be weighed to within 0.5 g. and then stored at a temperature of from 60 to 85° F. in an atmosphere of 25 to 50-per-cent relative humidity. The specimens shall be weighed once a day until the weight has become constant to within 0.1 per cent.

(*b*) *Procedure.*—The test specimen shall be centrally supported on fixed parallel bearings spaced 14 in. (350 mm.) between centers and the load-applying block brought in contact with the upper surface of the specimen midway between the supports. All bearings and load surfaces shall be true, shall engage the full width of the test specimen, and shall be rounded to a radius of $\frac{1}{8}$ in. (3.2 mm.). The test load shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ±10 per cent in the rate.

(*c*) *Report.*—Flexural strength test results shall be reported with the load applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM SHEATHING BOARD[1]

A.S.T.M. Designation: C 79 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1930; REVISED, 1931.

Definition. 1. Gypsum sheathing board is a gypsum plaster board designed to be used as a sheathing in buildings.

MANUFACTURE

Composition. 2. Gypsum sheathing board shall consist of an incombustible core of gypsum, with or without fiber, but not exceeding 15 per cent fiber by weight, and surfaced with paper or other fibrous material firmly bonded to the core.

PROPERTIES AND TESTS

Flexural Strength. 3. (*a*) When tested either face up or face down in accordance with the methods described in Section 14, specimens taken from the gypsum sheathing boards shall carry not less than the following loads without showing a breaking of the bond between the surfacing and the core:

Thickness, in.	Thickness, mm.	Load, lb. Knife Edges Across Fiber of Surfacing	Load, lb. Knife Edges Parallel to Fiber of Surfacing
½	12.7	110	50
¾	19.0	175	100

Sampling. 4. At least 1 per cent of the number of gypsum sheathing boards in a shipment, but not less than ten boards, shall be so selected as to be representative of the shipment. Twenty-five per cent of such selected boards, but not less than ten individual boards, shall constitute a sample for purposes of test. When a shipment consists of more than one car or carrier load, a sample shall be taken from each car or carrier.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 211 W. Wacker Drive, Chicago, Ill.

DIMENSIONS, WEIGHTS AND PERMISSIBLE VARIATIONS

Thickness. 5. The nominal thickness of gypsum sheathing board shall be either $\frac{1}{2}$ in. (12.7 mm.) or $\frac{3}{4}$ in. (19 mm.), with permissible variations in the nominal thickness of $\pm\frac{1}{32}$ in. (0.8 mm.) and with permissible local variations of $\pm\frac{1}{16}$ in. (1.6 mm.) from the nominal thickness.

Width. 6. The nominal width of gypsum sheathing board shall be either 24 in. (610 mm.) or 32 in. (810 mm.), with a permissible variation of $\pm\frac{1}{8}$ in. (3.2 mm.) from the specified width.

Length. 7. The nominal length of gypsum sheathing board shall be either 6 ft. 8 in. (2.03 meters) or 8 ft. (2.44 meters), with permissible variations of $\pm\frac{1}{4}$ in. (6.3 mm.) from the specified length.

Weight. 8. The weight of gypsum sheathing board per 1000 sq. ft. shall conform to the following requirements:

Thickness,		Weight per 1000 sq. ft.			
		Minimum,		Maximum,	
in.	mm.	lb.	kg.	lb.	kg.
$\frac{1}{2}$	12.7	1800	816	3000	1361
$\frac{3}{4}$	19.0	3000	1361	4000	1814

FINISH

Finish. 9. The edges and ends of gypsum sheathing board shall be straight and solid. The corners shall be square with a permissible variation of $\frac{1}{8}$ in. (3.2 mm.) in the full width of the board. Gypsum sheathing board shall be free from cracks and imperfections that will render them unfit for use.

PACKING AND MARKING

Packing and Marking. 10. Shipments of gypsum sheathing board shall conform to the following requirements:

(*a*) They shall be shipped so as to be kept dry and free from moisture.

(*b*) When shipped for resale, the following information shall be shown upon each board or package:

Name of manufacturer;
Brand.

INSPECTION AND REJECTION

Inspection. 11. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 12. Any rejection shall be based upon failure to conform to the requirements of these specifications and shall be reported within ten working days from the receipt of the shipment by the consignee. The notice of rejection shall contain a specific statement of the respects in which the boards have failed to conform to the requirements of these specifications.

Rehearing. 13. Claims for rehearing shall be valid only if made within 20 working days from the receipt of notice of specific cause for rejection.

METHOD OF TESTING

Flexural Strength Test. 14. (*a*) *Test Specimens.*—Test specimens for the flexural strength test shall be taken from not less than ten gypsum boards. The test specimens shall be 12 in. (300 mm.) in width and approximately 16 in. (410 mm.) in length. The specimens shall be weighed to within 0.5 g. and then stored at a temperature of from 60 to 85° F. in an atmosphere of 25 to 50-per-cent relative humidity. The specimens shall be weighed once a day until the weight has become constant to within 0.1 per cent.

(*b*) *Procedure.*—The test specimen shall be centrally supported on fixed parallel bearings spaced 14 in. (350 mm.) between centers and the load-applying block brought in contact with the upper surface of the specimen midway between the supports. All bearings and load surfaces shall be true, shall engage the full width of the test specimen, and shall be rounded to a radius of $\frac{1}{8}$ in. (3.2 mm.). The test load shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate.

(*c*) *Report.*—Flexural strength test results shall be reported with the load applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

TENTATIVE DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY[1]

A.S.T.M. Designation: C 11 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1916; REVISED, 1921, 1925, 1926, 1928, 1929, 1931.

Aggregate.—Any inert material used as a filler in stucco, plaster, mortar, concrete, etc., without regard to its function as a binding material.

Consistency.—A property of a material determined by the complete flow-force relation.

Gypsum Concrete.—A combination of aggregate or aggregates with gypsum as a binding medium, which after mixing solidifies into a conglomerate mass.

Gypsum Fiber Concrete.—Gypsum concrete in which the aggregate consists of shavings or chips of wood.

Gypsum Lath.—A gypsum plaster board, designed to be used as a base for the reception of gypsum plaster.

Gypsum Plaster Board.—A sheet or slab having an incombustible core of gypsum, containing not more than 15 per cent by weight of fiber, and surfaced with paper or other fibrous material firmly bonded to the core.

Gypsum Sheathing Board.—A gypsum plaster board, designed to be used as a sheathing in buildings.

Gypsum Wall Board.—A gypsum plaster board designed to be used, without the addition of plaster, for walls, ceilings, or partitions, and affording a surface suitable to receive decoration.

Plasticity.—A complex property of a material, involving a combination of the properties of mobility and of yield value.

NOTE.—A plastic material is distinct from a solid material in that it possesses mobility. It is distinct from a fluid material in that it requires a measurable force (yield value) to start flow.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 Wacker Drive, Chicago, Ill.

These Definitions, when adopted as standard, will be added to the present Standard Definitions of Terms Relating to the Gypsum Industry (A.S.T.M. Designation: C 11 - 28), 1930 Book of A.S.T.M. Standards, Part II, p. 137.

TENTATIVE SPECIFICATIONS
FOR
CONCRETE AGGREGATES[1]

A.S.T.M. Designation: C 33 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1926, 1928, 1930, 1931.

QUALITY OF AGGREGATES

It is recognized that for certain purposes satisfactory results may be obtained with materials not conforming to these specifications. In such cases the use of fine and coarse aggregates not conforming to these specifications may be authorized only under special provisions based upon laboratory studies of the possibility of designing a mixture of materials to be used on the job that will yield concrete equivalent in quality to the specified mixture made with material complying with these specifications in all respects.

FINE AGGREGATE

General Characteristics. 1. Fine aggregate shall consist of sand or other approved inert materials with similar characteristics, or a combination thereof, having hard, strong, durable particles and shall conform to the requirements of these specifications.

Deleterious Substances. 2. (*a*) The amount of deleterious substances shall not exceed the following maximum requirements:

	MAXIMUM PERMISSIBLE PERCENTAGE BY WEIGHT
Removed by decantation	3
Coal	1
Clay lumps	1
Other local deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles)	....
Total coal, clay lumps, shale, soft fragments and other local deleterious substances	5

NOTE.—It is recognized that under certain conditions percentages of deleterious substances less than those shown in the table should be specified as a maximum.

(*b*) All fine aggregate shall be free from injurious amounts of organic impurities. Aggregates subjected to the colorimetric test for organic impurities and producing a color darker than the standard shall be rejected unless they pass the mortar strength test as specified in Section 4.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

Grading.

3. (*a*) Fine aggregate shall be well graded from coarse to fine and when tested by means of laboratory sieves[1] shall conform to the following requirements:

	PER CENT
Passing a $\frac{3}{8}$-in. sieve	100
Passing a No. 4 sieve	(85) to (100)
Passing a No. 16 sieve	(45) to (80)
Passing a No. 50 sieve	(2) to (30)
Passing a No. 100 sieve	(0) to (5)

NOTE.—Figures in parentheses are suggested as limiting percentages but they may be altered within these limits to suit local conditions.

Uniformity.

(*b*) The above gradation for fine aggregate represents the extreme limits which shall determine the suitability for use of fine aggregate from all sources of supply. The gradation of fine aggregate from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity of a fine aggregate, a fineness modulus determination shall be made upon representative samples of fine aggregate, from such sources as are proposed for use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample submitted by the contractor shall either be rejected or may be accepted subject to such adjustment in proportions as may be necessary by reason of changes in grading of fine aggregate. Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction or mix, without permission from the engineer.

(*c*) In case the concrete resulting from a mixture of aggregates approaching the extreme limits for gradation is not of a workable character, or when finished does not exhibit a proper surface, due to an excess of particles approximately $\frac{1}{8}$ to $\frac{1}{2}$ in. in size, either a fine aggregate having a sufficiently greater percentage of fine material, or a coarse aggregate having a sufficiently smaller percentage of fine material shall be used.

Mortar Strength.

4. Fine aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test (Section 10 (*e*)) it shall develop a compressive strength at 7 and 28 days of not less than .... per cent[2] of that developed by a mortar prepared in the

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[1] For detail requirements for these sieves, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials, 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

[2] A percentage should be inserted by the engineer to suit local conditions.

same manner with the same cement and graded Ottawa sand having a fineness modulus of 2.40 ± 0.10.

NOTE.—The graded Ottawa sand mentioned above may be obtained with a mixture of approximately equal parts by weight of standard Ottawa sand and run-of-mine Ottawa sand.

COARSE AGGREGATE

General Characteristics. 5. Coarse aggregate shall consist of crushed stone, gravel, blast-furnace slag, or other approved inert materials of similar characteristics, or combinations thereof, having hard, strong, durable pieces, free from adherent coatings and conforming to the requirements of these specifications.

Deleterious Substances. 6. The amount of deleterious substances shall not exceed the following maximum requirements:

	MAXIMUM PERMISSIBLE PERCENTAGE BY WEIGHT
Removed by decantation	1½
Shale (removed by flotation test)	1
Coal	1
Clay lumps	0.5
Soft fragments	5
Other local deleterious substances (such as alkali, friable, thin, elongated, or laminated pieces)	....
Total shale, coal, clay lumps and soft fragments	5

NOTE.—It is recognized that under certain conditions percentages of deleterious substances less than those shown in the table should be specified as a maximum.

Grading. 7. (*a*) Coarse aggregate shall be well graded, between the limits specified, and shall conform to the following requirements:

CRUSHED STONE, GRAVEL AND BLAST-FURNACE SLAG

Designated Size	Percentages Passing Laboratory Sieves Having Square Openings						
	2 in.	1½ in.	1 in.	¾ in.	½ in.	⅜ in.	No. 4
2 in. to No. 4	95 to 100	....	35 to 70	....	10 to 30	....	0 to 5
1½ in. to No. 4	....	95 to 100	....	35 to 70	....	10 to 30	0 to 5
1 in. to No. 4	....	....	90 to 100	....	25 to 60	....	0 to 10
¾ in. to No. 4	....	....	....	90 to 100	....	20 to 55	0 to 10
½ in. to No. 4	....	....	....	....	90 to 100	....	0 to 15
2 in. to 1 in	90 to 100	35 to 70	0 to 15	....	....	....	......
1½ in. to ¾ in	....	90 to 100	20 to 55	0 to 15	....	....	......

(*b*) Designation of a given coarse aggregate as aggregate of a certain maximum size shall be understood to mean that more than 5 per cent must be retained on the next smaller of the sieves appearing in the above table.

(*c*) In case the concrete resulting from a mixture of aggregates approaching the extreme limits for gradation is not of a workable character, or when finished does not exhibit a proper surface, due to an excess of particles approximately $\frac{1}{8}$ to $\frac{1}{2}$ in. in size, either a fine aggregate having a sufficiently greater percentage of fine material or a coarse aggregate having a sufficiently smaller percentage of fine material shall be used.

Weight of Slag.

8. Blast-furnace slag that meets the grading requirements of these specifications shall conform to the following minimum weight requirements:

General concrete	65 lb. per cu. ft.
Concrete subject to abrasion	70 lb. per cu. ft.

Durability.

9. Coarse aggregate shall pass a sodium sulfate accelerated soundness test, except that aggregates failing in the accelerated soundness test may be used if they pass a satisfactory freezing and thawing test.

NOTE.—Many engineers believe that an abrasion test for coarse aggregate to be used in concrete subject to abrasion is important, but no test limits are specified, due to the status of knowledge concerning suitable specification limits for this test. The Committee believes that the abrasion tests when applied to blast-furnace slag do not meet the requirements for a desirable test. This recommendation is made after consideration of the results of a study to determine the value of the abrasion test as to the concrete making properties of slag.

METHODS OF SAMPLING AND TESTING

Methods of Testing.

10. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraphs (*i*) and (*j*):

(*a*) *Sampling.*—Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (A.S.T.M. Designation: D 75).[1]

(*b*) *Sieve Analysis.*—Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41).[2]

(*c*) *Decantation Test.*—Standard Method of Decantation Test for Sand and Other Fine Aggregates (A.S.T.M. Designation: D 136),[3] or the Standard Method of Test for Quantity of Clay and Silt in Gravel for Highway Construction (A.S.T.M. Designation: D 72).[4]

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 622.

[2] *Ibid.*, p. 155.

[3] *Ibid.*, p. 618.

[4] *Ibid.*, p. 620.

(*d*) *Organic Impurities.*—Standard Method of Test for Organic Impurities in Sands for Concrete (A.S.T.M. Designation: C 40).[1]

(*e*) *Mortar Strength.*—Tentative Method of Test for Structural Strength of Fine Aggregate, Using Constant Water-Cement-Ratio Mortar (A.S.T.M. Designation: C 87 – 31 T).[2]

(*f*) *Compressive Strength.*—Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39).[3]

(*g*) *Soundness.*—Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (A.S.T.M. Designation: C 89 – 31 T).[4]

(*h*) *Freezing and Thawing.*—Method of Freezing and Thawing Tests of Drain Tile as described in the Standard Specifications for Drain Tile (A.S.T.M. Designation: C 4).[5]

(*i*) *Shale and Coal.*—Proposed Method of Test for Percentage of Shale in Aggregate,[6] as adopted by the American Association of State Highway Officials.

(*j*) *Soft Fragments.*—Proposed Method of Test for Quantity of Soft Pebbles in Gravel[7] as adopted by the American Association of State Highway Officials.

(*k*) *Moisture.*—Standard Method of Test for Surface Moisture in Fine Aggregate (A.S.T.M. Designation: C 70).[8]

(*l*) *Weight of Slag.*—Standard Method of Test for Unit Weight of Aggregate for Concrete (A.S.T.M. Designation: C 29).[9]

(*m*) *Abrasion.*—If abrasion tests are made the following methods of test are recommended:

(1) *Abrasion of Gravel.*—Tentative Method of Test for Abrasion of Gravel (A.S.T.M. Designation: D 289 – 28 T).[10]

(2) *Abrasion of Rock.*—Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation: D 2),[11] except that for specific gravities lower than 2.2 a 4000-g. sample shall be used.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 154.

[2] See p. 767.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 143.

[4] See p. 773.

[5] 1930 Book of A.S.T.M. Standards, Part II, p. 256.

[6] Appendix III, 1928 Report of Committee C-9 on Concrete and Concrete Aggregates, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 362 (1928).

[7] Appendix IV, 1928 Report of Committee C-9 on Concrete and Concrete Aggregates, see *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 363 (1928).

[8] 1930 Book of A.S.T.M. Standards, Part II, p. 162.

[9] *Ibid.*, p. 151.

[10] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 940 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 519.

[11] 1930 Book of A.S.T.M. Standards, Part II, p. 609.

(*n*) *Fineness Modulus.*—The fineness modulus is the sum of percentages in the sieve analysis divided by 100 when the sieve analysis is expressed as cumulative percentages coarser than each of sieves Nos. 100, 50, 30, 16, 8, 4, etc. The sieves shall conform to the requirements of the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials.[1] The sieve analysis shall be made in accordance with the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (A.S.T.M. Designation: C 41) of the American Society for Testing Materials.[2]

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

[2] *Ibid.*, p. 155.

TENTATIVE SPECIFICATIONS
FOR
CURING PORTLAND-CEMENT CONCRETE[1]

A.S.T.M. Designation: C 80 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover the curing of concrete for all purposes, including necessary precautions during the curing period in cold weather.

PROCEDURE

Structures. 2. The concrete shall be so cured that the compressive[2] or flexural[2] strengths of specimens of the concrete 28 days old, are not less than 90 per cent of the strengths of 28-day-old specimens of the same concrete cured in moist air at a constant temperature of 70° F.

Methods for Testing. 3. All specimens shall be submerged in water for 24 hours just prior to being tested.

Procedure. 4. Test specimens, in so far as applicable, shall be made and tested in accordance with the following methods of the American Society for Testing Materials:

(*a*) *Compression Specimens.*—Standard Methods for Making and Storing Compression Test Specimens of Concrete in the Field (A.S.T.M. Designation: C 31).[3]

(*b*) *Compression Test.*—Standard Methods of Making Compression Tests of Concrete (A.S.T.M. Designation: C 39).[4]

(*c*) *Flexure Test.*—Tentative Laboratory Method of Making Flexure Tests of Concrete, Using a Simple Beam with Center Loading (A.S.T.M. Designation: C 78 - 30 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] Either compression or flexure should be selected according to whether the concrete is designed for compression or bending stresses.

[3] 1931 Supplement to Book of A.S.T.M. Standards, p. 58.

[4] 1930 Book of A.S.T.M. Standards, Part II, p. 143.

[5] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1027 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 251.

Exposed Slabs.

5. The concrete shall be cured[1] by any one of the following methods of the American Society for Testing Materials as specified by the engineer as suitable for the conditions of the work:

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Bituminous Coverings (A.S.T.M. Designation: C 81 - 31 T);[2]

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture (A.S.T.M. Designation: C 82 - 31 T);[3]

Tentative Specifications for Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride (A.S.T.M. Designation: C 83 - 31 T);[4] and

Tentative Specifications for Curing Portland-Cement Concrete Slabs with Wet Coverings (A.S.T.M. Designation: C 84 - 31 T).[5]

CURING DURING COLD WEATHER

Protected Concrete.

6. (*a*) Protected concrete when deposited shall have a temperature of not less than 50° F. nor more than 100° F. The freshly-deposited concrete and the surrounding air shall be maintained at a temperature of not less than 50° F. nor more than 100° F., until the concrete has attained 80 per cent of the strength for which the concrete was designed. The methods of protection and heating shall be such as to prevent evaporation of moisture from the concrete and injury to the surface during the period of protection.

(*b*) The temperature of the concrete shall be observed and the concrete examined for the presence of sufficient moisture at least twice each day.

Exposed Concrete.

7. Exposed concrete for which the surrounding air cannot be artificially heated shall not be placed when the air temperature is lower than 40° F. The concrete when deposited shall have a temperature of not less than 50° F. nor more than 100° F. When there is likelihood of freezing temperature prevailing during the curing period the concrete shall be protected by means of an insulating covering of sufficient thickness to prevent freezing until the concrete has attained 80 per cent of the strength for which the concrete is designed.

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[1] For a resumé of the current knowledge concerning the applicability and limitations of the various curing methods, see the report of Subcommittee XIII on Curing of Concrete of Committee C-9 on Concrete and Concrete Aggregates, see p. 331.

[2] See p. 758.

[3] See p. 760.

[4] See p. 761.

[5] See p. 762.

TENTATIVE SPECIFICATIONS
FOR
CURING PORTLAND-CEMENT CONCRETE SLABS WITH BITUMINOUS COVERINGS[1]

A.S.T.M. Designation: C 81 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover the method of curing exposed portland-cement concrete slabs, by maintaining the surface moisture of the concrete by means of a bituminous sealing coat.

Material. 2. The bituminous curing material shall be of such consistency at normal temperature that it can be forced through an atomizing nozzle and applied to the concrete as a fine mist. Within two hours after application it shall form a water-impermeable film and shall adhere strongly to the concrete.

Alternate Method "A":[2]

Procedure. 3. (*a*) *Wet Burlap Covering.*—After the final finishing operation the concrete shall be covered for not less than 24 hours by a double thickness of burlap, kept saturated with water. The burlap shall weigh when dry at least 7 oz. per sq. yd. It shall be handled in such a manner that contact with earth or other deleterious substances will be prevented. Burlap which becomes contaminated with earth or other deleterious substances shall be washed clean before use.

(*b*) *Bituminous Covering.*—After the removal of the burlap and as soon as the free surface water has disappeared, and before the concrete shows any signs of excessive drying as evidenced by lighter surface color or by the appearance of surface cracks or checks, the curing material shall be applied as a fine mist or spray by means of an approved pressure sprayer, in such a manner as to provide a continuous, uniform, water-impermeable film without marring the surface.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] The engineer shall specify the method that is to be used.

The rate of application shall be not less than .... nor more than .... gal. per sq. yd.[1]

Alternate Method "B":[2]

4. (*a*) *Bituminous Covering.*—As soon as possible after the free surface water has disappeared and before the concrete shows any signs of excessive drying as evidenced by lighter surface color or by the appearance of surface cracks or checks, the curing material shall be applied as a fine mist or spray by means of an approved pressure sprayer, in such a manner as to provide a continuous, uniform, water-impermeable film without marring the surface. The rate of application shall be not less than .... nor more than .... gal. per sq. yd.[1] **Procedure.**

(*b*) *Wet Burlap Covering.*—If for any reason the application of the bituminous curing material to any portion of the concrete surface cannot proceed at the proper time, that portion shall be covered immediately with wet burlap, which shall be kept wet until the concrete has set. The burlap shall be removed before 10.00 a. m. the following day, and the concrete immediately coated with the bituminous curing material.

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[1] The engineer shall insert the limiting values applying on specific contracts, depending upon the composition of the particular curing agent or agents to be used.

[2] The engineer shall specify the method that is to be used.

TENTATIVE SPECIFICATIONS
FOR
CURING PORTLAND-CEMENT CONCRETE SLABS WITH CALCIUM-CHLORIDE ADMIXTURE[1]

A.S.T.M. Designation: C 82 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover the method of curing exposed portland-cement concrete slabs by accelerating the setting and hardening of the concrete by means of calcium chloride solution incorporated with the mixture.

Calcium Chloride. 2. The calcium chloride shall conform to the Tentative Specifications for Calcium Chloride for Dust Prevention (A.S.T.M. Designation: D 98 – 30 T) of the American Society for Testing Materials.[2]

Calcium Chloride Solution. 3. A concentrated solution shall be prepared by adding 100 lb. of calcium chloride to 13 gal. of water previously placed in the container. The solution shall be thoroughly stirred until it is of uniform concentration and shall have a specific gravity of from 1.31 to 1.36 at 60° F.

Admixture Calcium Chloride Solution. 4. From 2 to 3 pt., according to the rate of set of the concrete, of the calcium chloride solution for each bag of cement (or for each 94 lb. of cement) shall be introduced into the drum of the mixer with the mixing water. A positive automatic mechanical method shall be used for introducing the calcium chloride solution into the mixer drum in company with the water.

Finishing Concrete. 5. The concrete shall be finished and edged promptly after placing, as concrete containing calcium chloride hardens rapidly.

Wet Burlap Covering. 6. After the final finishing operation the concrete shall be covered for not less than 24 hours by a double thickness of burlap, kept saturated with water. The burlap shall weigh when dry at least 7 oz. per sq. yd. It shall be handled in such a manner that contact with earth or other deleterious substances will be prevented. Burlap which becomes contaminated with earth or other deleterious substances shall be washed clean before use.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1145 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 490.

TENTATIVE SPECIFICATIONS

FOR

CURING PORTLAND-CEMENT CONCRETE SLABS BY SURFACE APPLICATION OF CALCIUM CHLORIDE[1]

A.S.T.M. Designation: C 83 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope.

1. These specifications cover the method of curing exposed portland-cement concrete slabs by maintaining the surface moisture of the concrete by means of surface application of calcium chloride.

Material.

2. The calcium chloride shall conform to the Tentative Specifications for Calcium Chloride for Dust Prevention (A.S.T.M. Designation: D 98 - 30 T) of the American Society for Testing Materials.[2]

Burlap Covering.

3. After the final finishing operation the concrete shall be covered by a double thickness of burlap, kept saturated with water. The burlap shall remain until the concrete will bear the weight of the workman without damage but in no case less than 12 hours. The burlap shall weigh when dry at least 7 oz. per sq. yd. It shall be handled in such a manner that contact with earth or other deleterious substances will be prevented. Burlap which becomes contaminated with earth or other deleterious substances shall be washed clean before use.

Application of Calcium Chloride.

4. (*a*) After removal of the burlap, 2 lb. of calcium chloride shall be applied to each square yard of the pavement surface. The material shall be spread by means of a squeegee or suitable mechanical device, and further shoveled or broomed if necessary to secure uniform distribution. Spreading shall not be done with shovels or brooms alone.

(*b*) All lumps of calcium chloride shall be broken up and distributed uniformly or removed. Calcium chloride shall not be applied during a rain, and if a rain occurs within 2 hours after placing, the calcium chloride shall be replaced.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1145 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 490.

TENTATIVE SPECIFICATIONS
FOR
CURING PORTLAND-CEMENT CONCRETE SLABS WITH WET COVERINGS[1]

A.S.T.M. Designation: C 84 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1931.

Scope. 1. These specifications cover the method of curing exposed portland-cement concrete slabs, by maintaining the surface moisture by means of wet coverings.

Burlap Coverings. 2. After the final finishing operation the concrete shall be covered for not less than 18 hours by a double thickness of burlap kept saturated with water. The burlap shall weigh when dry at least 7 oz. per sq. yd. It shall be handled in such a manner that contact with earth or other deleterious substances will be prevented. Burlap which has become contaminated by earth or other deleterious substances shall be washed clean before use.

Ponding, Earth, Straw, etc. 3. Immediately after the removal of the burlap the slab shall be protected by one of the following methods:

(*a*) *Ponding.*—The surface of the slab shall be kept covered with water for 7 days after the placing of the concrete.

(*b*) *Wet Earth, Sand or Sawdust.*—A 1-in. layer of thoroughly wet sand, earth or sawdust shall be maintained on the surface of the concrete for 7 days after the placing of the concrete. The earth shall be free from large lumps.

(*c*) *Wet Straw or Hay.*—A 6-in. layer of thoroughly wet straw, hay or similar material shall be maintained on the surface of the concrete for 7 days after the placing of the concrete.

Protection of Edge of Slab. 4. The edges of a slab exposed by the removal of the forms shall be protected immediately after the form removal in such a manner as to give these surfaces curing treatment equivalent to that provided by one of the preceding methods.

Removal of Curing Material. 5. At the end of the curing period the covering material shall be removed and disposed of as provided in the contract. Straw or other material shall not be burned upon the surface of the concrete.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

TENTATIVE METHOD OF ROUTINE ANALYSIS OF THE CEMENT CONTENT OF HARDENED PORTLAND-CEMENT CONCRETE[1]

A.S.T.M. Designation: C 85 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

1. This test is applicable to hardened portland-cement concretes except those containing certain aggregates or admixtures which liberate soluble silica under the conditions of the test such as slag, diatomites, and sodium silicate. **Scope.**

SOLUTIONS REQUIRED

2. The following reagents will be required: **Solutions Required.**

(*a*) *Hydrochloric Acid Solution* (approximately 3.3 *N*).—Add 200 cc. of concentrated HCl to 600 cc. of distilled H_2O.

(*b*) *Sodium Hydroxide Solution* (approximately 1.0 *N*).—Dissolve 20 g. of NaOH in 200 cc. of H_2O and make up to a volume of 500 cc.

(*c*) *Hydrofluoric Acid* (40 per cent solution).

(*d*) *Sulfuric Acid* (concentrated) or *Sodium Bisulfate* (crystalline).

SAMPLE

3. Every precaution shall be taken to have the sample of concrete used for analysis truly representative of the material under consideration. Several portions weighing at least 10 lb. each shall be taken to avoid all but slight inequalities of the concrete mix. These portions shall then be broken up, crushed in a suitable machine to about ½ in. in size, and reduced to a fineness of approximately 150 to 200-mesh in a ball mill, disk pulverizer or other device. Care shall be taken that the finer fractions of the broken sample, which are richer in cement, are not discarded or lost. After thorough mixing and quartering, a portion approximating 100 g. shall be taken and carefully freed, by means of a strong magnet, from particles of metallic iron abraded from the pulverizer or ball mill. The clean sample shall then be dried at 105° C. for at least two hours. **Preparation of Sample.**

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[1] **Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.**

METHOD

Method. 4. Weigh into each of three 250-cc. beakers, not less than a 2-g. portion of the prepared sample. Moisten with a stream of hot water and by stirring prevent adhesion to the beaker or the formation of lumps in the mass. Slowly add 100 cc. of 3.3 *N* HCl and stir thoroughly. The lumps which tend to form should be reduced with the glass rod. After the evolution of carbon dioxide has ceased and the reaction is apparently complete, heat gently for a few minutes and allow the contents of the beaker to settle. Decant through an ignited and weighed Gooch crucible which contains a mat of short asbestos shreds, practically insoluble in HCl, thick enough to be opaque to light. Once the filtration has begun, care shall be taken so that the mat and accumulated residue do not dry out completely until the filtration process is complete. Regulate the suction so as to maintain a rapid rate of dropping during the greater part of the filtration. Retain as much of the residue in the beaker as possible. Wash by decantation twice with hot water. Add 75 cc. of *N* NaOH solution to the residue while stirring and heat to about 75° C. Decant as before and wash twice with hot water. Transfer the residue to the crucible and wash with at least 60 cc. of hot water.

The filtrate now contains the silica in the form of silicic acid either in true solution or in suspension in the hydrochloric acid medium. If the aggregates of the original sample are largely calcareous or dolomitic add 10 cc. of concentrated HCl to the solution. Transfer to a suitable beaker, with several rinsings of the filter flask. Evaporate to dryness with great care to minimize the spattering, bake at not over 120° C. for an hour, moisten with concentrated HCl, evaporate and bake again, and take up for filtration in 75 cc. of 2-3 *N* HCl solution heated to boiling. Filter through an ashless filter-paper, wash the residue with 50 cc. of hot *N* HCl solution and then with hot water until the washings are free from chlorides. Repeat the evaporation and filtering processes to recover the small amounts of silica dissolved and add these to the first residue. The silica present in the sample is then determined in the usual way by treatment with HF and H_2SO_4 or by fusion with $NaHSO_4$.

Where the aggregates are available which were used in the concrete being analyzed, a blank test shall be run on these aggregates to determine their content of silica, soluble under the conditions of the test. This content of soluble silica shall then be used as a correction factor and be subtracted from the total soluble silica found in the concrete, the difference being due to the cement contained in the specimen.

5. The percentage of cement in the sample shall be calculated by dividing the percentage of silica found by the factor 0.2175,[a] provided it is not known that the silica content of the cement differs from this value. When possible, the known value shall be taken as the factor. **Calculation.**

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[a] For the correctness of this factor as an average silica content of American cements, see Report of Subcommittee I on Definitions and Chemical Limitations of Committee C-1 on Cement, *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, pp. 238 to 243 (1928).

TENTATIVE METHOD OF TEST
FOR
APPARENT SPECIFIC GRAVITY OF COARSE AGGREGATES IN A SATURATED CONDITION[1]

A.S.T.M. Designation: C 86 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. This method is intended for determining the apparent specific gravity of coarse aggregates in a saturated condition.

Weight in Air, Dry. 2. The sample, weighing 1000 g., shall consist of pieces approximately cubical or spherical in shape and retained on a screen having approximetely $\frac{3}{8}$-in. square openings. In the case of homogeneous material, the smallest particles in the sample may be retained on a screen having 1-in. square openings.

Weight in Air, Saturated. 3. The sample shall be immersed in water for 24 hours, and the individual pieces surface-dried with the aid of a towel or blotting paper, and weighed. Record this weight as weight *B*.

Weight in Water, Saturated. 4. The sample shall then be placed in a suitable wire basket of approximately $\frac{1}{4}$-in. mesh, suspended in water (the basket may be conveniently suspended by means of a fine wire hung from a hook shaped in the form of a question mark with the top end resting on the center of the scale pan) from the center of the scale pan, and weighed. Record the difference between this weight and the weight of the empty basket suspended in water as weight *C*, that is, the weight of the saturated sample immersed in water.

Calculation. 5. The apparent specific gravity shall be calculated by dividing the weight in air of the sample saturated for 24 hours and then surface-dried, *B*, by the difference between the weights of the saturated sample in air, *B*, and in water, *C*, as follows:

$$\text{Apparent Specific Gravity in Saturated Condition} = \frac{B}{B - C}$$

NOTE.—Attention is called to the distinction between apparent specific gravity and true specific gravity. Apparent specific gravity includes the voids in the specimen and is therefore always less than or equal to, but never greater than the true specific gravity of the material.

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[1] **Criticisms of this Tentative Method are solicited, and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.**

TENTATIVE METHOD OF TEST

FOR

STRUCTURAL STRENGTH OF FINE AGGREGATE USING CONSTANT WATER-CEMENT-RATIO MORTAR[1]

A.S.T.M. Designation: C 87 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope.

1. This test is intended for determining the "structural strength" of sands to be used as fine aggregate in concrete by means of a compression test on a mortar of plastic consistency and gaged to a definite water-cement ratio.

Mortar.

2. Cement and water in quantities[2] which will give a water-cement ratio of 0.9 shall be placed in an appropriate vessel[3] and the cement permitted to absorb water for 1 minute. The materials shall then be mixed with a spoon[3] into a smooth paste. Sand from a sample of known weight[2] shall then be beaten into the mixture until the material appears to be of the desired consistency (flow 100 ± 5). The mixing shall be continued for one-half minute, and a determination of the flow made.

Flow Test.

3. The consistency shall be measured by use of the 10-in. flow table consisting of a circular bronze plate 10 in. in diameter, so mounted that the surface is level, and equipped with a mechanism for raising the plate $\frac{1}{8}$ in. and allowing it to fall without cushioning. A right truncated cone, $2\frac{3}{4}$ in. in diameter at the top, 4 in. in diameter at the bottom, and 2 in. in height, shall be used to measure the volume of the mortar for the test. Immediately after mixing, the mortar shall be placed in the cone which has been carefully centered on the flow table. The mortar shall be rodded 25 times with a $\frac{3}{8}$-in. rod, the surplus struck off, the plate wiped clean, the cone removed, and the

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] For six 2-in. cubes, 600 g. of cement and 359 cc. of water will usually give sufficient mortar. The quantity of sand used with this amount of cement may vary from 1200 g. for fine sand to 2000 g. or more for coarse sand.

[3] The vessel used is an ordinary sauce pan of 4 qt. capacity, $9\frac{1}{2}$ in. in diameter at the top and $4\frac{1}{2}$ in. high. The spoon is a large iron kitchen spoon.

table given 30 drops in 30 seconds. The percentage of increase in the diameter of the base of the pat, measured on two diameters at right angles to each other, shall be known as the flow.

4. Should the flow be too great, the mortar may be returned to the mixing vessel, additional sand added, and another determination of the flow made. If the mortar is too dry, the batch shall be discarded. The quantity of sand used shall be determined by subtracting the weight of the portion remaining after mixing from the weight of the initial sample.

Molding Compression Specimens.

5. Immediately following the determination of the flow, the mortar shall be placed in 2 by 4-in. cylindrical molds in three layers, or 2-in. cubes in two layers, each layer rodded in place with 25 strokes of a $\frac{3}{8}$-in. rod, and the mold filled to overflowing. The specimens shall be placed in a moist closet for curing. Three to four hours after molding the specimens shall be struck off to a smooth surface. Twenty to twenty-four hours after molding, the specimens shall be removed from the molds and stored in water until tested.

Temperature.

6. The temperature of the mixing water, moist closet, and storage tank shall be maintained between 65 and 75° F.

Capping.

7. If the specimens are cylindrical, they shall be carefully capped with plaster of Paris before testing. Cubes made in suitable molds need not be capped and shall be tested at right angles to the direction of molding.

TENTATIVE METHOD OF TEST
FOR
SOUNDNESS OF FINE AGGREGATES BY USE OF SODIUM SULFATE[1]

A.S.T.M. Designation: C 88 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. This method of test is intended for testing fine aggregates to determine their resistance to a solution of sodium sulfate.

NOTE.—The results obtained with this test method shall be considered only as a guide in the selection of aggregates. It is not intended that the test shall be used as an arbitrary basis for rejection of the material without taking other factors into account; consideration should be given to the results obtained with the material when exposed to actual weathering conditions.

APPARATUS

Containers. 2. Suitable containers for immersing the samples of aggregate in the solution in accordance with the procedure hereinafter described shall be selected. The containers should be non-metallic or of metal not subject to corrosion by sodium sulfate.

NOTE—No standard form of container is recommended since different practices will be most convenient in various laboratories and the committee does not feel that this question, except for obvious fundamentals, is of importance. Two general methods of immersion have been used as follows:

(*1*) Each sample placed in a water-tight container and covered with the sodium-sulfate solution.

(*2*) Each sample placed in a container with a wire mesh bottom and immersed in a vat containing the sodium sulfate solution. Care should be taken to prevent loss by floatation if uncovered containers are submerged.

Temperature Regulation. 3. Suitable means for regulating the temperature of the sodium sulfate solution during the immersion of the samples shall be provided.

Weighing Equipment. 4. A balance having a capacity not less than 500 g., sensitive to at least 0.1 g., shall be used.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

Drying Oven. 5. The drying oven shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 105 to 110° C. (221 to 230° F.).

Sodium Sulfate Solution. 6. The sodium sulfate solution shall be saturated by dissolving the salt, either of the anhydrous (Na_2SO_4) or crystalline ($Na_2SO_4 \cdot 10\ H_2O$) form, in water at a temperature of 24 to 27° C. (75 to 80° F.). The solution shall be thoroughly stirred during the addition of the salt and sufficient excess salt shall be added to insure saturation. About 500 g. of the anhydrous form or 1000 g. of the decahydrate will be required for each liter of water. The solution shall be allowed to cool before use to a temperature of 21° C. ± 1° C. (70° F. ± 2° F.).

TEST SAMPLE

Sample of Fine Aggregate. 7. Fine aggregate for the test shall be passed through a $\frac{3}{8}$-in. sieve. The sample shall be of such size that it will yield not less than 100 g. of each of the following sizes present in amounts of 5 per cent or more, expressed in terms of sieves conforming to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials:[1]

Retained on Sieve No. 50, passing Sieve No. 30
" " " " 30, " " " 16
" " " " 16, " " " 8
" " " " 8, " " " 4
" " " " 4, " $\frac{3}{8}$-in. Sieve

Should the fine aggregate contain less than 5 per cent of any of these sizes, that size shall not be tested but, for the purpose of calculating the test results, shall be considered to have the same loss in sodium-sulfate treatment as the average of the sizes tested.

Preparation of Test Sample. 8. The sample shall be thoroughly washed on a No. 50 sieve and dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), and separated into the different sizes by sieving as follows:

Make a rough separation of the graded sample by means of a nest of the standard sieves specified in Section 7. From the fractions obtained in this manner select samples of sufficient size to yield 100 g. after sieving to refusal. In general, a 110-g. sample will be sufficient. Fine aggregate sticking in the meshes of the sieves shall not be used in preparing the samples. Samples consisting of 100 g. shall be weighed out of each of the separated fractions after final sieving and placed in separate containers for the test.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

PROCEDURE

Storage of Samples in Solution.

9. The samples shall be immersed in the prepared solution of sodium sulfate in such a manner that the solution covers them to a depth of at least ½ in. The containers should be covered to reduce evaporation and prevent the accidental addition of extraneous substances. The immersed samples shall be maintained at a temperature of 21° C. ± 1° C. (70° F. ± 2° F.) for a period of 18 hours.

NOTE.—A moist room such as is used for curing concrete and mortar test specimens offers a convenient means of controlling the storage temperature. The presence of a few crystals of sodium sulfate in the container is essential to keeping the solution saturated.

Drying Samples After Immersion.

10. After the 18-hour immersion period the aggregate samples shall be removed from the solution and placed in the drying oven. The oven shall have been brought previously to a temperature of 105 to 110° C. (221 to 230° F.). Care shall be exercised to avoid loss of any of the aggregate particles or detritus coarser than a No. 100 sieve. The samples shall be dried to constant weight at the specified temperature. After drying, the samples shall be allowed to cool to within the range of the temperature permissible for the solution in which they are to be immersed, when they shall again be immersed in the prepared solution as described in Section 9.

Cycles.

11. The process of alternate immersion and drying shall be repeated until the required number of cycles is obtained. Unless otherwise specified, five cycles shall constitute a test.

Examination.

12. The examination of the test sample shall be made as follows:

(*a*) After the completion of the final cycle and after the sample has cooled, the sodium sulfate shall be washed from the sample by means of warm water. This shall be done by soaking the sample in fresh, clean, warm water for approximately one hour, decanting the liquid and repeating this operation *at least* four times. Materials of high absorption may require a greater number of washings.

NOTE.—The operator should assure himself that this procedure washes the sample free of sodium sulfate by testing the wash water from each sample. Barium chloride ($BaCl_2$) solution will cause a precipitate if sodium sulfate is present

(*b*) After the sodium sulfate has been removed, each fraction of the sample shall be dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), weighed and screened over the same sieve on which it was retained before the test. The particles retained on the sieve shall be weighed and the weight recorded.

NOTE.—In addition to the procedure described in Paragraphs (*a*) and (*b*) the following is suggested as giving additional information of value:

Each fraction should be examined visually in order to determine if there is any evidence or excessive splitting of the sand grains.

After treating each separate fraction of sample as described in Paragraph (*b*), all sizes, including the detritus, shall be combined and a sieve analysis made using as many of the following sieves as are required: Nos. 100, 50, 30, 16, 8, 4. The results of the sieve analysis shall be recorded as cumulative percentages retained on each sieve.

REPORT

Report.

13. The report shall include the following:

(*a*) Weight of each fraction of sample before test.

(*b*) Material from each fraction of sample, finer than sieve on which fraction was retained before test, expressed as a percentage by weight of the fraction.

(*c*) Weighted average calculated from the percentages of loss for each fraction and based on the grading of the sample as received for examination.

TENTATIVE METHOD OF TEST
FOR
SOUNDNESS OF COARSE AGGREGATES BY USE OF SODIUM SULFATE[1]

A.S.T.M. Designation: C 89 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. This method of test is intended for testing coarse aggregates to determine their resistance to a solution of sodium sulfate.

NOTE—The results obtained with this test method shall be considered only as a guide in the selection of aggregates. It is not intended that the test shall be used as an arbitrary basis for rejection of the material without taking other factors into account; consideration should be given to the results obtained with the material when exposed to actual weathering conditions.

APPARATUS

Containers. 2. Suitable containers for immersing the samples of aggregate in the solution in accordance with the procedure hereinafter described shall be selected. The containers should be non-metallic or of metal not subject to corrosion by sodium sulfate.

NOTE.—No standard form of container is recommended since different practices will be most convenient in various laboratories, and the committee does not feel that this question, except for obvious fundamentals, is of importance. Two general methods of immersion have been used as follows:

(*1*) Each sample placed in a water-tight container and covered with sodium-sulfate solution.

(*2*) Each sample placed in a perforated container and immersed in a vat containing the sodium sulfate solution.

Temperature Regulation. 3. Suitable means for regulating the temperature of the sodium sulfate solution during the immersion of the samples shall be provided.

Weighing Equipment. 4. A balance having a capacity not less than 5000 g., sensitive to at least 1 g., shall be used.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, 545 Munsey Building, Washington, D. C.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

Drying Oven.

5. The drying oven shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 105 to 110° C. (221 to 230° F.).

Sodium Sulfate Solution.

6. The sodium sulfate solution shall be saturated by dissolving the salt, either of the anhydrous (Na_2SO_4) or crystalline ($Na_2SO_4 \cdot 10H_2O$) form, in water at a temperature of 24 to 27° C. (75 to 80° F.). The solution shall be thoroughly stirred during the addition of the salt and sufficient excess salt shall be added to insure saturation. About 500 g. of the anhydrous form or 1000 g. of the decahydrate will be required for each liter of water. The solution shall be allowed to cool before use to a temperature of 21° C. ± 1° C. (70° F. ± 2° F.).

TEST SAMPLE

Samples of Coarse Aggregate.

7. The coarse aggregate for the test shall consist of material from which the sizes finer than the No. 4 sieve have been removed. The sample shall be of such a size that it will yield not less than the following amounts of the different sizes present in amounts of 5 per cent or more:

No. 4 to ⅜-in. size	(square	openings)	100 g.
⅜ to ¾-in. size	"	"	300 g.
¾ to 1½-in. size	"	"	1500 g.
1½ to 2½-in. size	"	"	3000 g.
Larger sizes by 1-in. spread in sieve size			3000 g.

Should the sample of coarse aggregate contain less than 5 per cent of any of these sizes, that size shall not be tested but, for the purpose of calculating the test results, shall be considered to have the same loss in sodium sulfate treatment as the average of the sizes tested.

Preparation of Test Sample.

8. For making the sodium sulfate test on ledge rock, the sample shall be prepared by breaking it into fragments such that the weights of the fractions specified in Section 7 smaller than 2½ in. may be procured. The mechanical analysis of the entire sample of broken fragments shall be obtained after first sieving the sample through the 2½-in. sieve and rejecting the material passing the No. 4 sieve. The test shall then be made as described in Sections 9 to 14, using the mechanical analysis of the broken fragments for the purpose of weighting the percentages of loss of the several fractions.

The sample shall be thoroughly washed and dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), and separated into the different sizes by screening to refusal. The proper weight of sample for each fraction shall be weighed out and placed in separate containers for the test. In the case of fractions coarser than the ¾-in. sieve, the number of particles shall be counted.

PROCEDURE

Storage of Sample in Solution.

9. The samples shall be immersed in the prepared solution of sodium sulfate in such a manner that the solution covers them to a depth of at least ½ in. The containers should be covered to reduce evaporation and prevent the accidental addition of extraneous substances. The immersed samples shall be maintained at a temperature of 21° C. ± 1° C. (70° F. ± 2° F.) for a period of 18 hours.

NOTE.—A moist room such as is used for curing concrete and mortar test specimens offers a convenient means of controlling the storage temperature. The presence of a few crystals of sodium sulfate in the containers is essential to keeping the solution saturated.

Drying Samples After Immersion.

10. After the 18-hour immersion period the aggregate samples shall be removed from the solution and placed in the drying oven. The oven shall have been brought previously to a temperature of 105 to 110° C. (221 to 230° F.). Care shall be exercised to avoid loss of any aggregate particles.[1] The samples shall be dried to constant weight at the specified temperature. After drying, the samples shall be allowed to cool to within the range of temperature permissible for the solution in which they are to be immersed, when they shall again be immersed in the prepared solution as described in Section 9.

Cycles.

11. The process of alternate immersion and drying shall be repeated until the required number of cycles is obtained. Unless otherwise specified, five cycles shall constitute a test.

Examination.

12. Fractions of samples coarser than ¾ in. shall be examined qualitatively after each immersion and quantitatively at the completion of the test. Fractions finer than ¾ in. shall be examined quantitatively only, and after the completion of the test.

Qualitative Examination.

13. The qualitative examination and record shall consist of: (*1*) observing the effect of action by the sodium sulfate solution and the nature of the action, and (*2*) counting the number of particles affected.

NOTE.—Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking.

Quantitative Examination.

14. The quantitative examination shall be made as follows:

(*a*) After the completion of the final cycle and after the sample has cooled, the sodium sulfate shall be washed from the sample by means of warm water. This shall be done by soaking the sample in fresh, clean, warm water for approximately one hour, decanting the liquid and repeating this operation *at least* four times. Materials of high absorption may require a greater number of washings.

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[1] The detritus also should be saved if the complete analysis suggested in the Note in Section 14 (*b*) is made.

NOTE.—The operator should assure himself that this procedure washes the sample free of sodium sulfate by testing the wash water from each sample. Barium chloride ($BaCl_2$) solution will cause a precipitate if sodium sulfate is present.

(*b*) After the sodium sulfate has been removed, each fraction of the sample shall be dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), weighed and screened over the same sieve on which it was retained before the test. The weight of the material passing the sieve shall be determined and the weight recorded.

NOTE.—While only particles larger than the ¾-in. size are to be examined qualitatively it is recommended that examination of the smaller sizes be made in order to determine if there is any evidence of excessive splitting.

In addition to the procedure described in Paragraphs (*a*) and (*b*) the following is suggested as giving addional information of value: After treating each separate fraction of sample as described in Paragraph (*b*) all sizes, including the detritus, shall be combined and a sieve analysis made using a complete set of sieves for the determination of the fineness modulus. The results of the sieve analysis shall be recorded as cumulative percentages retained on each sieve.

REPORT

Report. 15. The report shall include the following:

(*a*) Weight of each fraction of sample before test;

(*b*) Number of particles in each fraction of sample coarser than ¾ in. before test;

(*c*) Number of pieces affected, in fractions coarser than ¾ in. only, classified as to number disintegrated, split, cracked, flaked, etc.;

(*d*) Material from each fraction of sample, finer than sieve on which fraction was retained before test, expressed as a percentage by weight of the fraction.

(*e*) Weighted average calculated from the percentages of loss for each fraction, based on the grading of the sample as received or, in the case of ledge rock, as prepared by breaking into particles for the test.

TENTATIVE METHOD OF CONTROL TEST
FOR
RESISTANCE OF FIRE-CLAY BRICK TO THERMAL SPALLING ACTION[1]

A.S.T.M. Designation: C 38 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1926, 1927, 1931.

Object.

1. This method of control test is intended for determining the comparative resistance of high-duty fire-clay brick to spalling action by subjecting them to repeated rapid temperature changes. It is not to be used as a suitability test, as experience has shown that results obtained in this control test are not comparable with results obtained in service on the same brand of brick. This test is of value, however, as a control test in maintaining the uniformity of fire-clay brick in so far as thermal spalling is concerned.

Preparation of Samples.

2. (*a*) The sample shall consist of at least five standard 9-in. brick or of five shapes, which may be cut to standard size with a grinding wheel.

(*b*) Test specimens of shapes such as boiler arch brick shall be cut to the standard 9-in. size. For this purpose a "cut-off" wheel is recommended.

Procedure.

3. (*a*) The specimens shall be weighed and placed in a door of a furnace operated at 1350° C. (2462° F.), care being taken to prevent the direct heating of more than the $2\frac{1}{2}$ by $4\frac{1}{2}$-in. end. After one hour the specimen shall be withdrawn from the furnace and stood on end in a tank of flowing cold water from 10 to 21° C. (50 to 70° F.) so that the hot end of the brick will be immersed to a depth of 2 in. After three minutes the sample shall be withdrawn from the water, allowed to steam five minutes and then returned to the furnace. The door of the furnace shall be closed while the bricks are out to prevent the lowering of the temperature. The alternate heating and cooling

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, Box 935, Baltimore, Md.

shall be continued in hourly cycles until a loss of 20 per cent by weight has occured in each brick.

(*b*) When pieces begin to fall off, the sample shall be laid on a 4.5 by 9.0-in. asbestos board, divided into 50 equal squares, and the approximate percentage of loss estimated after each removal from the water. After the completion of the test, the brick shall again be weighed and the percentage of loss determined.

Reporting Results.

4. The report shall show for each brick the number of dips before loss started, the percentage of loss after each cooling and the total number of dips until a loss of 20 per cent by weight has occurred.

TENTATIVE DEFINITIONS OF TERMS RELATING TO HEAT TRANSMISSION OF REFRACTORIES[1]

A.S.T.M. Designation: C 71 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1930.

Heat Transmission Terms

Thermal Conductivity.—The thermal conductivity of a homogeneous material is the rate of heat flow, under steady conditions, per unit area, and per unit temperature gradient, in the direction perpendicular to the area.

Thermal Resistivity.—Thermal resistivity is the reciprocal of thermal conductivity.

Resistance.—The resistance of a body between two iso-thermal surfaces is equal to the difference between the temperatures of the iso-thermal surfaces necessary to maintain unit rate of heat flow.

Conductance.—The conductance of a body between two iso-thermal surfaces is equal to the rate of heat flow through the body, per unit difference between the temperatures of the iso-thermal surfaces.

Film Resistance.—The film resistance at the boundary between a fluid and another medium in contact with it is equal to the differences between the temperature of the body of the fluid and that of the medium in contact with it, necessary to maintain unit rate of heat flow.

Surface Coefficient.—The surface coefficient at the boundary between a fluid and another medium in contact with it is equal to the rate of heat flow through the film per unit area of contact surface and unit difference between the temperature of the main body of the fluid and that of the medium in contact with it.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, Box 935, Baltimore, Md.

These definitions, when adopted as standard, will be added to the Standard Definitions of Terms Relating to Refractories (A.S.T.M. Designation: C 71 – 31), 1931 Supplement to Book of A.S.T.M. Standards, p. 72.

Total Resistance.—The total resistance to heat flow is the sum of the individual resistances through which the heat flows in series, from one medium to another.

Transmittance.—The transmittance of a system in which heat flows from one medium to another through one or more intermediate resistances, is equal to the rate of heat flow from one medium to the other divided by the difference in the temperature of the two media.

Transmission.—The transmission is the net rate of the heat flow from one medium to another, for conditions under consideration regardless of kind of transfer.

Heat Transmission Symbols

	SYMBOL
Area (normal to the path of heat flow)	A
Temperature, deg. Fahr. or deg. Cent.	t
Temperature, deg. Fahr. absolute or deg. K (deg. Cent. absolute)	T
Length of path of heat flow (thickness)	L
Total quantity of heat transferred	Q
Thermal transmission (heat transferred per unit time)	q
Thermal conductivity	k

TENTATIVE SPECIFICATIONS AND TESTS FOR LOAD-BEARING CONCRETE MASONRY UNITS[1]

A.S.T.M. Designation: C 90 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

SPECIFICATIONS

Scope.

1. These specifications apply to strength, absorption and general requirements of hollow load-bearing concrete masonry wall units made from portland cement and suitable aggregates such as sand, gravel, crushed stone, bituminous or anthracite cinders, burned clay or shale, and blast-furnace slag.[3]

COMPRESSIVE STRENGTH

Compressive Strength.

2. The average compressive strength of five units at the time of delivery to the site shall be not less than the following:

MINIMUM FACE SHELL THICKNESS, IN.	COMPRESSIVE STRENGTH BASED ON GROSS AREA, LB. PER SQ. IN. MEAN OF FIVE TESTS	INDIVIDUAL MINIMUM
1¼ or over	700	600
Under 1¼ and over ¾	1000	800

ABSORPTION

Absorption.

3. (*a*) Concrete masonry units which will be exposed to the weather or soil in the finished work (without brick, stucco or other suitable protective covering approved by the purchaser) shall not absorb more than 15 lb. of water per cubic foot of concrete actually contained.

(*b*) Units which will be suitably protected from the weather or soil in the finished work need not conform to the absorption requirement specified in Paragraph (*a*).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. D. Foster, Secretary of Committee C-10 on Hollow Masonry Building Units, Ohio State University, Columbus, Ohio.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

[3] When fire tests are required they shall be conducted in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (A.S.T.M. Designation: C 19 - 26 T), see *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 761 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 315.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions. 4. No dimension shall vary more than 3 per cent over or under the specified dimension for any form or size of unit.

WORKMANSHIP AND FINISH

Workmanship and Finish. 5. (*a*) All units shall be sound and free from cracks or other defects as would interfere with the proper placing of the unit or impair the strength or permanence of the construction.

(*b*) Units which are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to give good bond.

MARKING

Marking. 6. All units shall bear a distinctive mark of the manufacturer or shall otherwise be readily identified as to origin.

INSPECTION AND REJECTION

Inspection. 7. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified in the contract. The inspection shall be based on the requirements specified above. At least ten days from the time of sampling shall be allowed for the completion of tests. All tests shall be made in accordance with the methods specified in Sections 10 to 25.

Rejection. 8. Individual units shall be rejected for failure to meet size or workmanship and finish requirements. In case of failure to meet the strength and/or absorption requirements, the manufacturer may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of samples fails to meet the test requirements the entire set shall be rejected.

Expense of Tests. 9. Except as specified in Section 8 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

METHODS OF TESTING

SAMPLING

Selection of Samples for Test. 10. Samples of units for testing shall be selected and tested by the purchaser or by a competent representative authorized by him to do this work. In all cases the samples shall be representative of the whole lot of units from which they are selected. Full-size units shall be taken in all cases.

Number of Samples. 11. For the strength and absorption determinations, ten individual units shall be selected from each lot of 10,000 units or fraction thereof; 20 individual units from each lot of more than 10,000 and less than 100,000 units. For lots of more than 100,000 units ten individual units shall be selected from each 50,000 units contained in the lot. Where the absorption determination is not required the number of units taken may be reduced by half.

Time and Place of Selecting Samples.

12. Samples for the strength and absorption tests shall be selected at the factory or at the site of the work, as specified.

Marking Samples.

13. All units selected for purpose of tests shall be plainly and permanently marked for reference by the testing operator.

COMPRESSIVE STRENGTH TESTS

Samples.

14. Five full-size units shall be used. The units shall be in an air-dry condition equivalent to that obtained by a period of seven days' protection from the weather at room temperature at from 60 to 80° F.

Speed of Testing Machine.

15. The speed of the moving head of the testing machine shall be not more than 0.05 in. per minute.

Bearing Block.

16. A spherical bearing block of proper design shall be placed on top of the test specimen. When the bearing area of the spherical bearing block is not sufficient to cover the area of the specimen, metal plates of sufficient thickness to prevent appreciable bending shall be placed between the spherical bearing block and the specimen.

Capping.

17. (*a*) Bearing surfaces of the test specimens and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with shellac and allowed to dry.

(*b*) A quantity of plastic mortar made of a mixture of one part (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*c*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall be not more than $\frac{1}{8}$ in. Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

Time of Testing.

(*d*) When the cement-gypsum cap is used it shall age at least six hours before the unit is tested. Where time is not available for aging the cement-gypsum cap, a cap of neat gypsum may be used. Where the neat gypsum cap is used the unit may be tested as soon as the plaster has been well set, but not sooner than one hour after the sample has been capped.

(*e*) When sufficient time for hardening permits or when the surfaces of the samples are irregular, a capping of 1:2 portland-cement mortar may be used.

Position of Unit. 18. All units shall be tested in a position such that the load is applied in the same direction as in service.

Calculation. 19. The compressive strength of a unit shall be the maximum load applied divided by the gross cross-sectional area in square inches.

ABSORPTION TESTS

Selection of Test Samples. 20. The samples shall consist of five whole units or pieces from each one of five units. If pieces are used they shall weigh not less than one-third the weight of the whole unit from which they were taken and in no case less than 5 lb. The samples shall have had any loose particles removed and any rough or jagged edges ground smooth.

Marking Test Samples. 21. Each piece shall be marked so that it may be identified at any time with the unit from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the piece shall be used.

Drying Test Samples. 22. Preparatory to the absorption tests, all samples shall be dried in a drier or oven at a temperature between 100 and 115° C. (212 and 239° F.) and weighed at 24-hour intervals until the loss in weight does not exceed 1 per cent of the last previous weight.

Accuracy of Weighings. 23. The balance used shall be accurate to within 0.5 per cent of the weight of the smallest unit or piece tested.

Saturation of Samples. 24. The dry weight of the samples shall be obtained after which they shall be immersed completely in water at room temperature at from 15.6 to 26.7° C. (60 to 80° F.) for 24 hours. The samples shall then be weighed while suspended with a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for 60 seconds by placing on $\frac{3}{8}$-in. or coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed.

Calculations. 25. The absorption in pounds per cubic foot is equal to 62.4 times the difference between the wet and dry weights divided by the difference between the wet and suspended immersion weights, as follows:

$$\text{Absorption, lb. per cu. ft.} = \frac{(\text{Wet Weight} - \text{Dry Weight}) \times 62.4}{\text{Wet Weight} - \text{Suspended Immersion Weight}}$$

TENTATIVE SPECIFICATIONS AND TESTS
FOR
SOLUBLE NITROCELLULOSE[1]

A.S.T.M. Designation: D 301 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1929; REVISED, 1930, 1931.

Scope.

1. These specifications cover the material known as soluble nitrocellulose (also known as soluble cotton), which is shipped wet to conform to the regulations of the Interstate Commerce Commission.

PROPERTIES AND TESTS

Properties and Tests.

2. (*a*) *Appearance.*—The nitrocellulose shall not be discolored and shall be free from lumps and foreign matter, such as charred particles.

(*b*) *Ash.*—The ash content shall not exceed 0.30 per cent, calculated on the basis of dry-weight soluble nitrocellulose.

(*c*) *Nitrogen.*—The percentage of nitrogen, calculated on the basis of dry-weight soluble nitrocellulose, shall be within the limits mutually agreed upon by the buyer and seller for the particular type of soluble nitrocellulose.

(*d*) *Stability.*—The stability as determined by the 134.5° C. test shall not be less than 25 minutes.

(*e*) *Consistency* (*Viscosity*).—The consistency shall be within the limits mutually agreed upon by the buyer and seller for the particular type of soluble nitrocellulose.

(*f*) *Solubility and Appearance of the Solution.*—The solubility and appearance of the sample shall be equal to the standard for the particular type of soluble nitrocellulose.

(*g*) *Film Test.*—The film test of the sample shall be equal to that of the standard for the particular type of soluble nitrocellulose.

(*h*) *Toluol Dilution Test.*—The toluol dilution value of the sample shall be equivalent to that of the standard for the particular type of soluble nitrocellulose.

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed to Mr. P. H. Cathcart, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

METHOD OF SAMPLING

Sampling. 3. Samples shall be taken from not less than 10 per cent (at least two barrels) of each lot or batch in the shipment. In sampling the barrels two samples of approximately 1 pt. each shall be taken from two well separated points at least 1 ft. beneath the surface of the material in the barrel. These samples shall then be composited to represent each lot or batch in the shipment.

METHODS OF TESTING

ASH

Procedure. 4. The percentage of ash shall be determined as follows:

Weigh approximately 2 g. of the sample in a tared and ignited crucible and dry for approximately 30 minutes at 100° C. Determine the dry weight of the sample. Moisten the residue with 20 to 30 drops of c.p. nitric acid and heat on a steam bath until the sample is decomposed to a gummy mass. If necessary to complete the decomposition, add several additional drops of nitric acid at intervals. Then heat the crucible slowly over a bunsen burner or in an electric furnace until all volatile matter is driven off. Finally, ignite at red heat to constant weight, cool and weigh.

$$\text{Percentage of ash} = \frac{\text{Wt. of ash}}{\text{Wt. of dry sample}} \times 100$$

NOTE.—Danger from inflammable vapor may be avoided by a preliminary air drying of the sample in the event that the number of samples being tested or the construction of the oven are such as to warrant this precaution.

NITROGEN

Apparatus. 5. Use the duPont nitrometer[1] which is illustrated in Figs. 1 to 4. Figure 2 (*b*) shows the universal measuring tube, although the nitrocellulose measuring tube shown in Fig. 2 (*a*) is preferable for testing nitrocellulose. If desired, both measuring tubes may be included in the assembly, by replacing the 3-way glass manifold with a 4-way manifold.

Procedure. 6. The percentage of nitrogen shall be determined as follows:

NOTE 1.—The cellulose acetate mask must be worn during the generation and measurement of the gas as a precaution in case of an explosion.

NOTE 2.—Nitrogen-free c.p. sulfuric acid shall be used.

(*a*) Accurately calibrate the measuring tube in the usual manner, using mercury as the calibrating liquid.

(*b*) Standardize the apparatus using c.p. potassium nitrate recrystallized twice from distilled water and then washed with 95-per-cent ethyl alcohol, ground to pass a 100-mesh screen, and dried for 2 to 3 hours at 135 to 150° C. Fill the compensating, measuring and reaction tubes and their connections with mercury. Run 20 to 30 cc. of 94.5 ±0.5 per cent sulfuric acid (see Note 2) into the reaction bulb through the cup at the top and let in about 210 cc. of air.

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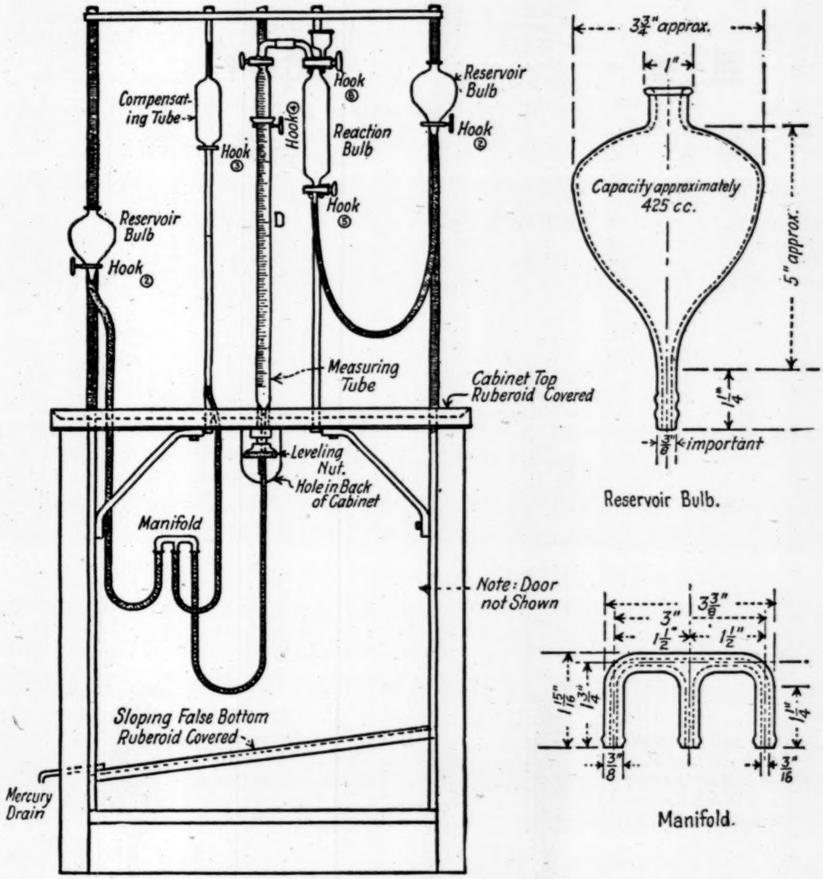
[1] Drawings reproduced by permission from the Standard Specifications for Laboratory Apparatus Adopted by the Manufacturing Chemists' Association of the United States, Part I.

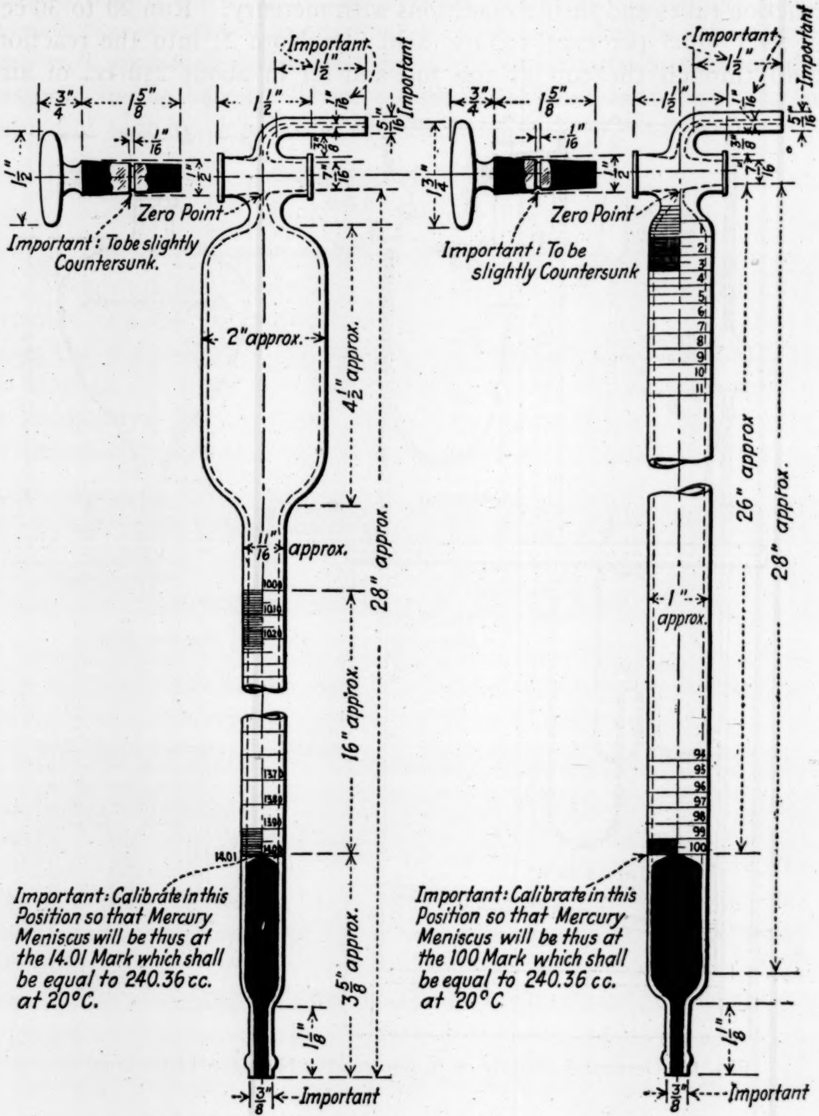

Compensating Tube
Hook ③
Hook ④
Hook ⑥
Reaction Bulb
Hook ⑤
Reservoir Bulb
Hook ②
Reservoir Bulb
Hook ②
D
Measuring Tube
Cabinet Top Ruberoid Covered
Leveling Nut.
Hole in Back of Cabinet
Manifold
Note: Door not Shown
Sloping False Bottom Ruberoid Covered
Mercury Drain
3¾" approx.
1"
Capacity approximately 425 cc.
5" approx.
1¼"
3/8"
important
3 3/8"
3"
1½"
1½"
1 15/16"
1¾"
1¼"
3/8"
3/16"

Reservoir Bulb.

Manifold.

FIG. 1.—General Assembly of Apparatus for Nitrogen Determination.

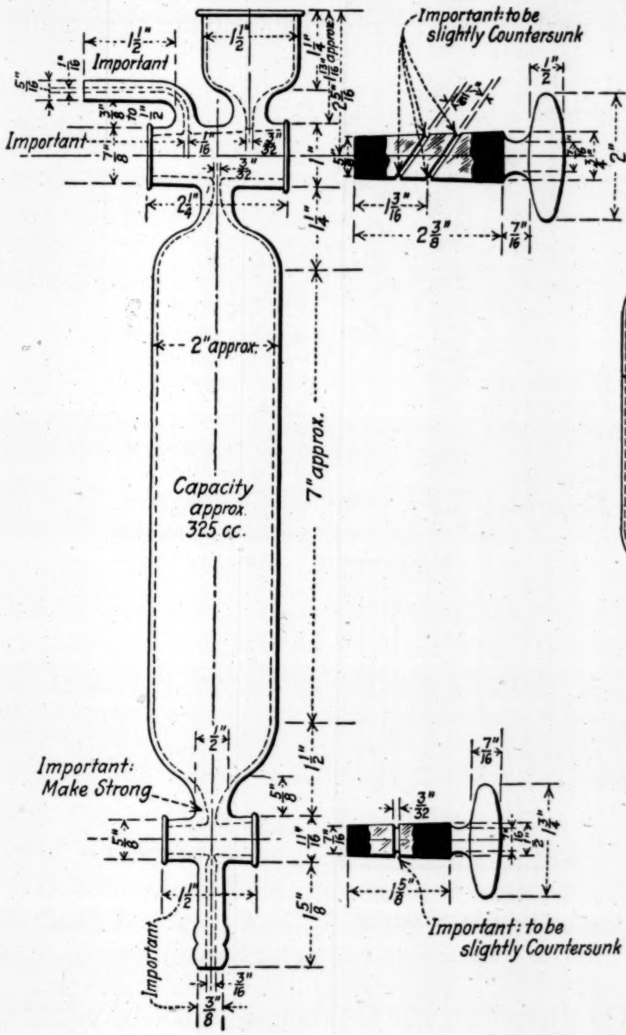
Close the stopcocks and shake the bulb well. This desiccates the air which is then run into the compensating tube until the mercury is about on a level with the 12.50 per cent mark on the measuring tube, the two tubes being held at the same height. Then seal the compensating tube using a small, blow-pipe flame. Accurately weigh 0.9000 to 1.0000 g. of the potassium nitrate and introduce into the reaction bulb. Wash the cup with 20 cc. of 94.5 ±0.5 per cent c.p. sulfuric acid (see Note 2) in three or four portions, each portion being run separately into the bulb. During this operation allow the bottom stopcock of the reaction bulb to remain open. Then with the bottom stopcock still open lower the reservoir bulb to give reduced pressure


Important
1/2"
Important
3/4"
1 5/8"
1 1/2"
1/16"
5/16"
1/16"
1 1/2"
1/2"
3/8"
7/16"
Zero Point
Important: To be slightly Countersunk.
2" approx.
4 1/2" approx.
28" approx.
11/16" approx.
1009
1010
1020
16" approx.
1370
1380
1390
1400
14.01
Important: Calibrate in this Position so that Mercury Meniscus will be thus at the 14.01 Mark which shall be equal to 240.36 cc. at 20°C.
3 5/8" approx.
1 1/8"
3/8"
Important
Important
1/2"
Important
3/4"
1 5/8"
1 1/2"
1/16"
1/16"
5/16"
1 3/4"
1/2"
3/8"
7/16"
Zero Point
Important: To be slightly Countersunk
1
2
3
4
5
6
7
8
9
10
11
26" approx
28" approx.
1" approx.
94
95
96
97
98
99
100
Important: Calibrate in this Position so that Mercury Meniscus will be thus at the 100 Mark which shall be equal to 240.36 cc. at 20°C
1 1/8"
3/8"
Important

(*a*) Nitrocellulose tube. (*b*) Universal tube.

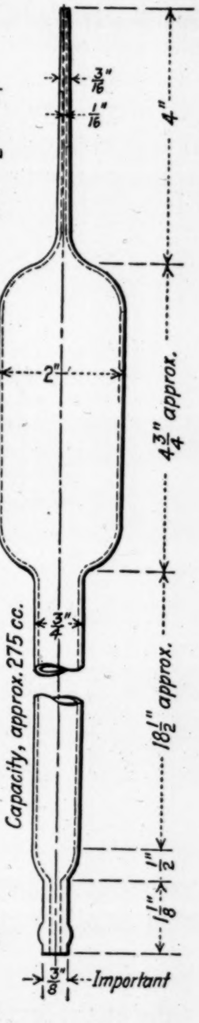
FIG. 2.—Measuring Tubes for Nitrogen Determination.

in the reaction bulb and gently shake the reaction bulb to start the decomposition. After the evolution of NO has become slow (it is extremely important that the bottom stopcock be left open until the major part of the decomposition has occurred; otherwise sudden



Important
Important
Important: to be slightly Countersunk
2" approx.
Capacity approx. 325 cc.
7" approx.
Important: Make Strong
Important: to be slightly Countersunk
Important

FIG. 3.—Reaction Bulb.



4"
2"
4 3/4" approx.
Capacity, approx. 275 cc.
18 1/2" approx.
Important

FIG. 4.—Compensating Tube.

evolution of gas will burst the bulb scattering acid and glass) lower the reservoir bulb until all but 25 cc. of the mercury in the reaction bulb is withdrawn, close the bottom stopcock and shake the reaction bulb vigorously for 5 minutes. When the reaction is completed allow the gas to cool for 20 minutes, then transfer the gas to the measuring tube. By means of the leveling device make careful adjustment of the mercury levels so that the mercury in the measuring tube is at the 13.85-per-cent mark (the theoretical percentage of nitrogen in potassium nitrate) if exactly a 1.0000-g. sample was used or a proportional reading if less was used. Paste a strip of paper on the compensating tube at the level of the mercury and the standardization is completed. It is advisable to make several check determinations, preferably on different days, to insure accurate standardization. Determinations should check within ±0.01 per cent.

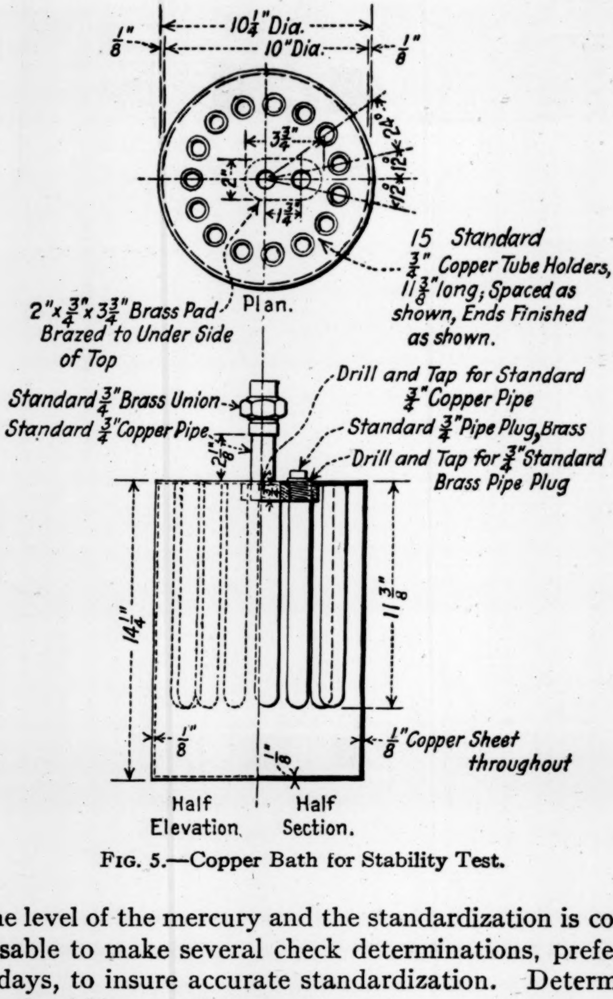

1/8"
10¼" Dia.
10" Dia.
1/8"
3¾"
24°
12°
12°
12°
12°
2"
1¾"
15 Standard ¾" Copper Tube Holders, 11⅜" long; Spaced as shown, Ends Finished as shown.
2"x¾"x3¾" Brass Pad Brazed to Under Side of Top
Plan.
Drill and Tap for Standard ¾" Copper Pipe
Standard ¾" Brass Union
Standard ¾" Copper Pipe
Standard ¾" Pipe Plug, Brass
Drill and Tap for ¾" Standard Brass Pipe Plug
2⅛"
14¼"
11⅜"
1/8"
1/8"
1/8" Copper Sheet throughout
Half Elevation.
Half Section.

FIG. 5.—Copper Bath for Stability Test.

(*c*) Roughly dry the soluble nitrocellulose as for the ash determination described in Section 4 and weigh a sample of from 1.0 to 1.5 g. in a weighing bottle. Dry to constant weight at 98 to 102° C.

(1 to $1\frac{1}{2}$ hours usually suffices) and cool in a desiccator. Transfer to the cup of the reaction bulb of the nitrometer; then, using 94.5 ±0.5-per-cent c.p. sulfuric acid dissolve the sample, withdraw into the reaction bulb and rinse the cup into the bulb several times. Use a total of 20 cc. of acid for dissolving and rinsing. Complete the determination in accordance with the standardization of the apparatus described in Paragraph (*b*) and take a reading after adjusting the level of the mercury in the reading tube to the mark on the compensating tube. The reading divided by the weight of sample gives the percentage of nitrogen.

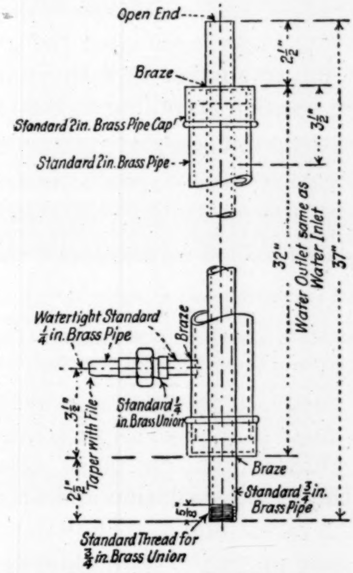

Open End
Braze
Standard 2 in. Brass Pipe Cap
Standard 2 in. Brass Pipe
$2\frac{1}{2}''$
$3\frac{1}{2}''$
32"
Water Outlet same as Water Inlet
37"
Watertight Standard $\frac{1}{4}$ in. Brass Pipe
Braze
Standard $\frac{1}{4}$ in. Brass Union
$3\frac{1}{2}''$
Taper with File
$2\frac{1}{2}''$
Braze
Standard $\frac{3}{4}$ in. Brass Pipe
$\frac{5}{8}$
Standard Thread for $\frac{3}{4}$ in. Brass Union

FIG. 6.—**Brass Condenser for Stability Test Apparatus.**

STABILITY

Apparatus.

7. The apparatus shall consist of the following:

(*a*) *Copper Bath.*—Copper bath with copper or brass condenser, as shown in Figs. 5 and 6. These baths are usually made to hold 13 or 15 test tubes.

(*b*) *Test Tubes.*—Fifteen Pyrex glass test tubes 290 mm. ± 1 mm. in length with an outside diameter of 18 mm. and a wall thickness of 1.5 mm.

(*c*) *Heater.*—An electric hot plate for heating the bath.

(*d*) *Face Mask.*—A face mask, so constructed that a heavy piece of clear cellulose-acetate celluloid sheeting protects the face.

(*e*) *Gloves.*—A pair of heavy gloves.

(*f*) *Pincers.*—Long pincers for handling the test tubes.

(g) *Thermometer.*—A mercury-filled thermometer graduated in centigrade degrees, the range being 130 to 140° C. in 0.1° C. Diameter, $\frac{5}{16}$ in. $\pm$ $\frac{1}{16}$ in.; over-all length, 18 in. $\pm$ $\frac{1}{4}$ in.; length of bulb, $2\frac{3}{8}$ in. $\pm$ $\frac{1}{4}$ in.; distance from bulb to first graduation, $8\frac{5}{8}$ in. $\pm$ $\frac{1}{4}$ in.; distance from lowest graduation to highest graduation, $4\frac{3}{4}$ in. $\pm$ $\frac{1}{4}$ in. Solid stem, white enamel back. Graduations to be numbered at 130, 135 and 140° C. The first and each succeeding 0.5° C. line to be longer than the remaining lines. All graduation lines and figures to be etched on the stem clear cut and distinct. Reservoir at the top to accommodate expansion up to 175° C. Accuracy to be within 0.2° C. over entire scale.

Solution Required.

8. *Methyl Violet Test Paper.*—Conduct the preparation and drying of the methyl violet test paper in a room that is free of acid fumes. Prepare a dye solution according to the following formula:

Pararosaniline[a] (converted to acetate)	0.2500 g.
Crystal violet	0.1680 g.
C.p. glycerin	6 cc.
Distilled water	30 cc.
95-per-cent ethyl alcohol	sufficient to make-up to 100 cc.

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[a] The pararosaniline acetate used in the foregoing formula is made by adding an excess of glacial acetic acid to 0.2500 g. of pararosaniline and heating in a porcelain casserole over a steam bath until the excess acid is removed. The other ingredients are then added and volume made up to a total of 100 cc. with 95-per-cent ethyl alcohol. The crystal violet mentioned in the formula may be replaced by Methyl Violet N.E. (E.I. duPont de Nemours and Co.) or Methyl Violet 2 B (National Aniline and Chemical Co.)

Place a small quantity of the dye solution into a rectangular glass tray that is supported in a tilted position. Slowly draw a quarter sheet of filter paper through the solution and up and over the side of the dish to remove the excess liquid. The filter paper shall be carefully selected and of such properties as to maintain a permanent color when treated. The S and S No. 597 filter paper has been found to be the only paper giving consistent results. Holding the sheet horizontally, wave it gently back and forth for about one minute, then suspend vertically until dry. When dry, cut into strips 70 by 20 mm. and store in a well-stoppered bottle.

Check each batch of prepared test papers against the papers held as standard by testing the same sample of nitrocellulose with both papers.

Procedure

9. Stability shall be determined by the 134.5° C. stability test, as follows:

Conduct the test in a room that is free of acid fumes. Dried nitrocellulose is very inflammable and if ignited by fire, spark or static electricity will flare up and shatter the test tube. It is important, therefore, that the operator wear the cellulose acetate mask and heavy gloves and that the tubes be handled with long pincers.

Maintain the heating bath at a temperature of 134.5° C. ±0.5° C. by the use of the required mixture of toluol and xylol. The proper mixture is approximately one part toluol and four parts xylol, but the exact proportions must be determined by the "cut-and-try" method. If the mixture started with is too high, add more toluol; if it is too low, allow the condenser to run hot until the desired temperature is reached. On continued operation the tendency is for the temperature to rise, which should be corrected by adding toluol.

Weigh accurately 2.5 g. of the sample previously dried for 4 to 5 hours at 40 to 45° C. or air dried over night followed by a drying for 30 minutes at 40 to 45° C. Shake or press the sample down in the test tube so that it occupies the lower two inches of the tube and swab out all nitrocellulose particles, adhering to the inside wall of the tube. Place the methyl violet test paper in the tube so that its lower edge is 1 in. from the top of the sample in which position the paper must remain throughout the test. Stopper the tube with a cork provided with a hole or notch 4 mm. in diameter to allow for expansion and contraction of the air in the tube. Place the tube containing the sample in the heating bath maintained at a temperature of 134.5° C. ±0.5° C. The tube must project not less than 5 nor more than 7 mm. above the top of the bath. Beginning at the end of the first twenty minutes, inspect the tube at 5-minute intervals by lifting the tube until the methyl violet paper, but not the soluble nitrocellulose, is visible above the surface of the bath. The end point is reached when the test paper completely loses its violet color. For example, if the color is not completely changed in 20 minutes but is completely changed in 25 minutes the stability of the sample is recorded as 25 minutes.

CONSISTENCY, FILM AND TOLUOL DILUTION TESTS

SOLUTIONS REQUIRED

Solutions Required.

10. The solutions used shall conform to the following formulas:

	FORMULA A	FORMULA B	FORMULA C	FORMULA D
Soluble nitrocellulose (dried at 50° C. to constant weight), per cent by weight	12.2	20.0	25.0	12.2
Ethyl acetate,[a] per cent by weight	17.5	16.0	15.0	....
Denatured alcohol, completely denatured (No. 5, 188-190 proof), per cent by weight	22.0	20.0	18.75	....
Toluol,[b] per cent by weight	48.3	44.0	41.25	....
Normal butyl acetate,[c] per cent by weight	....	....	....	87.8

[a] Ethyl acetate conforming to the requirements of the Tentative Specifications for Ethyl Acetate (85 to 88 per cent Grade) (A.S.T.M. Designation: D 302 - 30 T) of the American Society for Testing Materials.[1]

[b] Non-corrosive toluol, 2° C. boiling range, including the boiling point of toluene, 110.7° C.

[c] Normal butyl acetate conforming to the requirements of the Tentative Specifications for Normal Butyl Acetate (88 to 92 per cent Grade) (A.S.T.M. Designation: D 303 - 30 T) of the American Society for Testing Materials.[2]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1080 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 363.

[2] *Ibid.*, pp. 1082 and 365, respectively.

CONSISTENCY

Apparatus.

11. (*a*) *Cylinder.*—A glass cylinder 1.0 in. ±0.02 in. (25.4 mm. ±0.5 mm.) in inside diameter, 14 in. in height, and with marks 10.0 in. ±0.10 in. (254.00 mm. ±2.5 mm.) on the side at points about 2 and 12 in. from the top.

(*b*) *Steel Ball.*—A steel ball 0.3120 to 0.3130 in. (0.794 cm. ±0.001 cm.) in diameter and weighing 2.035 g. ±0.010 g.

Procedure.

12. (*a*) *Consistency* (*Viscosity*).—Consistency is determined by putting the soluble nitrocellulose in solution using a standard formula and noting the rate at which a standard steel ball drops through the solution.

Formula A, B or C is usually used for determining consistency. Use Formula A unless the sample gives a viscosity with it of 6 seconds or less, in which case use Formula B, if below 3 seconds in Formula B use Formula C. The solution of the nitro-cellulose will be completed somewhat more quickly if the alcohol and toluol be added first and the mixture be then allowed to stand 5 or 10 minutes before the ethyl acetate is added. Completely dissolve the sample in the solvent mixture by agitating in a tightly-closed container. Fill the glass cylinder with this solution. Stopper the cylinder, allow to stand until all air bubbles have passed out of the solution and bring to a temperature of 25.0° C. ±0.1° C. Place the cylinder in a vertical position and release the steel ball at the center of the upper surface of the solution and allow it to fall through the solution. The number of seconds required for the ball to pass through the 10-in. column of solution between the 2 and 12-in. marks on the cylinder, is recorded as the consistency of the sample.

(*b*) *Report.*—In reporting the consistency prefix the letter A, B or C to the value of the consistency determined in Paragraph (*a*) in order to indicate the solution formula used.

Solubility and Appearance.

13. *Solubility and Appearance of the Solution.*—Compare either Formula A, B, C or D (Note) with a freshly-prepared standard solution of the same type of soluble nitrocellulose of the same formula. Make the comparison in small vials and note the color, turbidity, "grain," and "flock."

NOTE.—Formula A, B or C which was prepared for the consistency determination is ordinarily used. When the soluble nitrocellulose is to be used for purposes requiring extreme transparency and clarity, use Formula D.

FILM TEST

Film Test.

14. Dilute Formula A, B or C with an equal volume of normal butyl acetate and pour the solution beside a freshly-prepared standard

solution, of the same type of soluble nitrocellulose, of the same formula, on a clean glass plate. Allow to dry in a nearly vertical position in a dust-free atmosphere. Compare the sample with the standard for undissolved particles, which indicate un-nitrated cotton or impurities, and for poor flow and poor gloss.

TOLUOL DILUTION TEST

Toluol Dilution Test.

15. To 50 cc. of Formula D in a stoppered bottle, add c.p. toluol (Note) in small quantities from a burette, shaking well after each addition. The first permanent separation of soluble nitrocellulose is taken as the dilution value and is expressed as a percentage by volume of Formula D.

NOTE.—Large quantities of butyl acetate and toluol should be reserved for this test to avoid possible variation between different lots.

TENTATIVE SPECIFICATIONS

FOR

ACETONE[1]

A.S.T.M. Designation: D 329 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Properties. 1. Acetone shall conform to the following requirements:

Purity	not less than 98 per cent dimethylketone
Specific gravity, 20°/20° C	0.791 to 0.799
Color	water white
Distillation range:[a]	
Below 55.0° C	none
Above 57.5° C	none
Non-volatile matter	not more than 0.005 g. per 100 ml.
Water	miscible without turbidity with 19 volumes of 60° Baumé gasoline at 20° C.
Acidity (free acid as CO_2)	not more than 0.002 per cent, equivalent to 0.051 mg. KOH per gram of sample
Water solubility	miscible with distilled water in all proportions
Alkalinity	not alkaline to para-nitrophenol
Potassium permanganate test	color of added potassium permanganate to be retained at least 30 minutes

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[a] The thermometer used for the distillation test shall conform to the requirements of the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150° C., 0 to +300° F. (A.S.T.M. Designation: D 182) of the American Society for Testing Materials.[2]

Methods of Testing. 2. The sampling and methods of testing shall be conducted in accordance with the Tentative Methods of Sampling and Testing Lacquer Solvents and Diluents (A.S.T.M. Designation: D 268 – 31 T) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. H. Cathcart, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1113.

[3] See p. 799.

TENTATIVE METHOD OF TEST
FOR
TINTING STRENGTH OF WHITE PIGMENTS[1]

A.S.T.M. Designation: D 332 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

1. This method is intended for determining the tinting strength of pigments and is best used for comparison of standard and sample of the same type of white pigment. **Scope.**

APPARATUS

2. The apparatus shall consist of the following: **Apparatus.**

(*a*) *Glass Plate.*—A glass plate of convenient size, the surface of which has been lightly ground with emery flour and turpentine.

(*b*) *Burette.*—A weighing bottle or burette for dispensing the oil.

(*c*) *Spatula.*—A spatula with a fairly stiff blade approximately 10 cm. in length and 16 mm. in width.

MATERIALS

3. The following materials will be required: **Materials.**

(*a*) A standard white pigment, mutually agreed upon.

(*b*) A low-strength, uniform, black tinting material.

NOTE.—While any uniform, finely-ground, low-strength black pigment may be used, it is advisable to prepare such a pigment from the finest lampblack and the finest precipitated calcium carbonate by grinding in a ball mill a mixture of one part of the dry lampblack and six parts of the dry calcium carbonate until a uniform mixture is obtained which will give check results with several duplicate samples of a standard white pigment.

(*c*) Bleached linseed oil which has approximately the characteristics of pure raw linseed oil.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. P. H. Cathcart, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

PROCEDURE

Procedure. 4. The tinting strength of pigments shall be determined as follows:

(*a*) Weigh accurately 1 g. of the standard white pigment and a sufficient amount of the black tinting material to produce a gray paste which will have a 20-per-cent light reflection when mixed with the oil (see Note), and place on the glass plate. Add from the weighing bottle or burette an amount of oil sufficient to produce a paste of medium consistency, work the materials into a smooth paste and then rub the paste continuously for three minutes with the spatula.

NOTE.—The light reflection may be measured by the Martens photometer or other suitable instrument, or by comparison with a paste known to have the specified light reflection.

(*b*) Treat 1 g. of the unknown sample of white pigment in exactly the same way as the standard white pigment, using sufficient black tinting material to produce a gray paste which will exactly match the standard gray paste. Sufficient oil shall be used with the unknown sample of white pigment to produce a paste with approximately the same consistency as the standard gray paste. Various amounts of the black tinting material shall be rubbed up with 1-g. portions of the unknown sample of white pigment until the color of the standard gray paste is exactly matched.

Calculation. 5. The tinting strength of the unknown sample shall be calculated from the following formula:

$$\text{Tinting strength of pigment} = \frac{\text{wt., in grams, of black used with unknown sample}}{\text{wt., in grams, of black used with standard sample}} \times T$$

where T = the empirical tinting strength value given to the standard white pigment.

TENTATIVE METHODS OF SAMPLING AND TESTING LACQUER SOLVENTS AND DILUENTS[1]

A.S.T.M. Designation: D 268 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1927: REVISED, 1929, 1930, 1931.

1. These methods cover the sampling and tests to be applied to solvents and diluents for use in the manufacture of nitro-cellulose lacquer. **Scope.**

SAMPLING

2. (*a*) The method of sampling specified in Paragraph (*b*) or (*c*) shall be used, according to the special conditions that obtain. **Sampling.**

(*b*) *From Loaded Tank Car or Other Large Vessel.*—The composite sample taken shall not be less than ½ gal. and should consist of small samples of not more than 1 qt. each, taken from near the top and bottom by means of a metal or glass container with removable stopper or top. This device, attached to a suitable pole, shall be lowered to the desired depth, when the stopper or top shall be removed and the container allowed to fill.

(*c*) *Barrels and Drums.*—At least 5 per cent of the packages in any shipment shall be represented in the sample. The purchaser may increase the percentage of packages to be sampled at his discretion, and it is recommended that every package be sampled in the case of expensive solvents that are bought in small quantity. A portion shall be withdrawn from about the center of each package sampled by means of a "thief" or other sampling device. The composite sample thus obtained shall not be less than 1 qt. and shall consist of equal portions of not less than ½ pt. from each package sampled.

METHODS OF TESTING

3. The specific gravity shall be determined by any convenient method that is accurate to the third decimal point, the temperature of both sample and water being 20° C. **Specific Gravity.**

4. The sample and the standard mutually agreed upon by the buyer and seller shall be compared in 100-ml. Nessler tubes having **Color.**

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. P. H. Cathcart, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

colorless bottoms and the sides of which are covered with opaque paper for the purpose of eliminating sidelight. The tubes should be filled to a height of approximately 24.5 cm., and shall be viewed from a point directly above the tube, using a white background beneath the bottom of the tube. For a solvent to be rated water-white, the visible color shall not be darker than a solution of 0.0030 g. of potassium bichromate in one liter of water when tested in the above manner.

Distillation. 5. The distillation test shall be conducted in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials,[1] with the following exceptions:

(*a*) The temperature of the end point of the distillation, which shall be termed the "dry point," is the temperature observed on the distillation thermometer when the last drop of liquid leaves the bottom of the distillation flask. The thermometer used shall conform to the requirements of either the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150 °C., 0 to +300° F. (A.S.T.M. Designation: D 182)[2] or the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, −5 to +300° C., +20 to +580° F. (A.S.T.M. Designation: D 183)[3] of the American Society for Testing Materials, as specified.

(*b*) Observations of volumes of distillate shall be made at the temperature specified for the individual solvent or diluent under test.

Non-Volatile Matter. 6. Non-volatile matter of solvents and diluents shall be determined as follows:

One hundred milliliters of the sample shall be placed in a weighed porcelain evaporating dish and evaporated almost to dryness on a steam bath. It shall then be heated in an oven at 100 to 110° C. to constant weight. The increase in the weight of the dish is the non-volatile matter of the sample, which should be expressed in grams per 100 ml.

Residual Odor. 7. Residual odor shall be determined for all solvents and diluents in which residual odor is an important property. Strips of heavy filter paper, of the same size and shape, shall be dipped to the same depth in beakers or wide-mouthed bottles containing the sample and the standard. The filter papers shall be allowed to dry in air at room temperature and shall be examined at suitable intervals for difference in odor.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 491.

[2] *Ibid*, p. 1113.

[3] *Ibid*, p. 1115.

8. Five milliliters of the sample shall be transferred to a 100-ml. glass-stoppered cylinder, and 60° Baumé gasoline added in 5-ml. portions, shaking well after each addition. Both sample and gasoline shall be at a temperature of 20° C. when used. Water is indicated by turbidity. If turbidity develops, the standard shall be tested in the same way and compared. **Water.**

9. Using a pipette, 50 ml. of the sample shall be transferred to a small Erlenmeyer flask and titrated with 0.1*N* KOH in 99-per-cent methyl alcohol, using phenolphthalein as an indicator. The weight of the sample shall be determined from the specific gravity and the acidity reported as milligrams of KOH per gram of sample and in the case of esters the results are also to be expressed as a percentage by weight of the approximate acid. **Acidity.**

10. (*a*) Alkalinity of solvents and diluents shall be determined only when indicated by the results obtained in Section 9. Using a pipette, 50 ml. of the sample shall be transferred to a small Erlenmeyer flask and titrated with 0.1*N* H_2SO_4, using methyl orange as an indicator. The weight of the sample shall be determined from its specific gravity and the alkalinity reported as milligrams of KOH per gram of sample. **Alkalinity.**

(*b*) *Alkalinity of Acetone.*—To 100 ml. of acetone contained in a small Erlenmeyer flask, add 0.3 ml. of 0.01 *N* H_2SO_4 and 0.5 ml. of 0.3-per-cent aqueous paranitro phenol. The reaction shall not be alkaline to paranitro phenol.

11. (*a*) One to two grams of the sample shall be weighed in an ampoule, by first weighing the empty ampoule, warming and filling, and then sealing-off and reweighing, The ampoule shall be placed in a 200-ml. Erlenmeyer flask which contains approximately one and one-half times the theoretical quantity of 0.5*N* alcoholic KOH required for complete saponification. The ampoule should be broken with a stirring rod and the flask connected with a reflux condenser. The flask shall then be heated on a steam bath for one to four hours, depending upon the ester being tested. During the heating the set-up and contents should be shaken frequently, taking the usual precautions to lose none of the contents. After the apparatus has cooled, the condenser shall be washed down with distilled water and three drops of phenolphthalein added to the contents of the flask as an indicator. The contents of the flask shall be titrated with 0.5*N* HCl. Two blanks with alcoholic KOH shall be run along with the sample. These blanks should check to the first decimal point. The result shall be reported as percentage of ester by weight, allowing in the calculations for acidity or alkalinity as determined in Sections 9 and 10. **Ester Value.**

(*b*) *Optional Method.*—One to two grams of the sample shall be weighed in an ampoule by first weighing the empty ampoule, warming and filling, and then sealing off and reweighing (Note). The ampoule shall be placed in a pressure bottle of approximately 325-ml. capacity (the spring top magnesium-citrate bottle is satisfactory) which contains one and one-half times the theoretical quantity of 0.5*N* alcoholic KOH required for complete saponification. The ampoule may be broken with a glass rod, subsequently washing the liquid adhering to the rod back into the bottle. After thorough agitation the bottle and contents shall be heated on a steam bath for 1 to 4 hours, depending upon the ester being tested. After the proper heating, the bottle shall be allowed to cool, then opened and the under side of the stopper and the sides of the neck washed down with distilled water. Three drops of the phenolphthalein solution shall be added to the contents of the flask as an indicator. The contents of the flask shall be titrated therein with 0.5*N* HCl. Two blanks with alcoholic KOH shall be run along with the sample. These blanks should check, on titration, to the first decimal point. The result should be reported as percentage of ester by weight, making allowance in the calculations for acidity or alkalinity as determined in Sections 9 and 10.

NOTE.—An optional method of weighing the sample is in a small weighing bottle, removing the stopper, by means of a glass rod after introduction into the pressure bottle, or by agitating the contents of the pressure bottle.

Copper Corrosion Test.

Apparatus.

12. The apparatus for the copper corrosion test shall consist of the following:

(*a*) *Flask.*—A 300-ml. flask of chemically-resistant glass with flat bottom and vial mouth.

(*b*) *Glass Condenser.*—A 12-in. glass condenser with the diameter of the condenser tube not less than $\frac{3}{8}$ in. A cork stopper to connect the flask with the condenser.

(*c*) *Copper Strip.*—A copper strip $2\frac{1}{2}$ in. by $\frac{1}{4}$ in. made from No. 20 B. & S. gage, cold-rolled, polished copper, approximate thickness 0.032 in. and having a $\frac{1}{16}$-in. hole, $\frac{1}{8}$ in. from one end. A piece of soft copper wire about 6 in. in length.

(*d*) *Water Bath.*—A water bath of convenient size and design.

Procedure.

13. The copper corrosion test shall be made as follows:

Both sides of the entire copper strip, edges excepted, shall be polished with a No. 00 emery cloth and used immediately to avoid discoloration by the atmosphere. A 6-in. length of soft copper wire shall be fastened through the hole provided near one end of the strip, care being taken not to touch the strip with the fingers after polishing. The strip shall be placed in the flask and 200 ml. of the material to be tested shall be added. The material must not contain separated water and shall be filtered through filter paper if necessary to remove water. The flask shall be connected to the vertical reflux condenser by means of a properly bored cork stopper. It is absolutely necessary that cork and not rubber stoppers be used, in order to avoid contamination of the material by sulfur from rubber stoppers. The copper wire may be allowed to extend into the condenser tube for convenience in removing the strip. The strip shall be completely immersed and should preferably lie flat and touch the flask only at the ends of the strip. The flask shall be placed in the water bath which should be just gently boiling and the flask immersed to the liquid line of the material within the flask. The copper strip shall be removed 30 minutes from the time the flask was immersed in the bath. Care should be taken not to touch the copper strip but to remove it by the wire which has been provided. The strip shall not be allowed to come in contact with separated water during any part of the test due to the fact that water causes bad local staining of the copper. If it is desired to preserve the strip for future reference it should be dipped immediately in white shellac or lacquer. The sheared edges of the test strip shall not be used as a basis for judgment; flat surfaces only shall be considered.

Sulfur.

14. *Sulfur (Hydrogen Sulfide and Sulfur Dioxide) in Benzols, Toluols, and Kindred By-Products.*—The qualitative test for hydrogen sulfide and sulfur dioxide shall be made at the time of performing the distillation test by hanging strips of moistened lead acetate paper and starch iodate paper on the end of the condenser tube. If the lead acetate paper shows discoloration, H_2S is present but not SO_2. In this case both papers will usually be discolored. If the lead acetate paper shows no discoloration but the starch iodate paper develops a blue color, SO_2 is present but not H_2S. If neither paper shows discoloration, neither H_2S nor SO_2 is present.

Determination of Dimethylketone.

15. *Reagents.*—The following reagents will be required:

(*a*) *Sodium Thiosulfate* (0.05 *N*).—Sodium thiosulfate shall be made up and standardized carefully against $K_2Cr_2O_7$. For accurate work, standardized burettes shall be used and burette corrections and temperature corrections applied. The 50-ml. burettes with Bureau of Standards certificates are recommended, both for the standardization of solutions and for the actual determination of acetone.

(*b*) *Iodine* (0.1 *N*).—0.1 *N* iodine shall be made up and standardized at the time of making a determination. The standardization consists in titrating against the 0.05 *N* $Na_2S_2O_3$, 50 ml. of iodine mixed with the same amounts of NaOH and H_2SO_4 as are used in the determination of acetone. The titrations are made in triplicate and the average of the three with burette and temperature corrections is used as the blank in making the calculations.

(*c*) *Sodium Hydroxide.*—Normal NaOH shall be made up and standardized against 2 N H_2SO_4.

(*d*) *Sulfuric Acid.*—2 N H_2SO_4 shall be made up and checked against normal NaOH and the strength adjusted so that 25 ml. of the acid will neutralize 50 ml. of the NaOH.

(*e*) *Starch Solution.*—Stir up 2 to 3 g. of potato starch or 5 g. of soluble starch with 100 ml. of 1-per-cent salicylic acid solution, add 300 to 400 ml. boiling water, and boil the mixture until the starch is practically dissolved. Dilute to 1 liter.

16. *Preparation of Sample.*—Approximately 1.4 g. of acetone shall be carefuly weighed by one of the following methods and made up to a volume of 1 liter:

(*a*) Glass ampules $\frac{5}{8}$ to $\frac{3}{4}$ in. in diameter shall be blown and after filling with acetone shall be sealed. The exact weight of sample shall be determined by the difference in weight of the empty and filled ampule. Samples varying in weight more than ±0.1 g. from 1.4 g. shall be rejected. The glass ampules shall be dropped into 500-ml. glass-stoppered bottles containing 200 ml. of boiled distilled water and broken by shaking. The capillary stem shall then be carefully crushed with a glass rod to allow thorough washing out of the acetone and the sample and combined washings made up to 1 liter at 20° C.

(*b*) A quick easy method is to weigh out 1.75 ml. of acetone from a 2-ml. pipette graduated in 0.1 ml. into a small glass-stoppered weighing bottle, conical shape, capacity 12 to 15 ml. This volume will weigh approximately 1.4 g. The weighing bottle shall be inverted and the mouth held under the surface of freshly boiled distilled water in a 1-liter beaker. The stopper shall then be removed under water by means of a glass rod with a hook on the end. The bottle shall be thoroughly washed out and the water and acetone transferred to a 1-liter flask and made up to the mark at 20° C.

17. *Procedure.*—Three 25-ml. aliquots from each of three flasks prepared in accordance with Section 16 (*a*) or (*b*) shall be pipetted into separate 750-ml. Erlenmeyer flasks containing 50 ml. each of the 1 N NaOH solution. A Bureau of Standards pipette shall be used for taking the samples from the flasks. Into each flask while shaking constantly shall be run 50 ml. of the 0.1 N iodine. The flasks shall then be stoppered and allowed to stand at about 20° C. (cooling necessary in warm weather) for at least 20 minutes. At the end of

this time, 26 ml. of the 2 *N* H_2SO_4 shall be poured into the first flask which shall then be titrated immediately against 0.5 *N* $Na_2S_2O_3$. The solution shall be acid before any thiosulfate is added; otherwise, the determination will be ruined. When the color of the iodine has almost faded out, starch solution shall be added and the titration continued until the blue color disappears and the bright yellow color of the iodoform suspension is reached. The milliliters of thiosulfate shall be read, the burette and temperature corrections applied and the corrected reading subtracted from the average corrected blank. Percentage of dimethylketone by weight shall then be calculated from the following formula:

$$\text{Acetone, per cent by weight} = \frac{(\text{milliliters of } Na_2S_2O_3 \text{ for blank} - \text{milliliters of } Na_2S_2O_3 \text{ for sample}) \times N \times 0.9675 \times 40}{\text{Weight of acetone taken for dilution}}$$

Note.—The following precautions shall be observed:

1. Only boiled distilled water shall be used in preparing the solutions and throughout the determination.

2. Standardized glassware shall be used and burette and temperature corrections shall be applied to all readings.

3. Weight of sample taken and amount of iodine solution used shall be as specified. With these amounts, the 35 to 40 per cent excess of iodine, found to be optimum for completion of the iodoform reaction will be present. Use of the small glass-stoppered bottle described in Section 16 (*b*) with the 2-ml. pipette insures uniformity in the weight of sample taken.

4. The iodine solution shall be added slowly and with constant shaking. The Bureau of Standards calibrated burette with fine tip and delivery time of approximately 2 minutes have been found very satisfactory.

5. A slight excess of acid shall be added just before the titration with thiosulfate. Too great an excess will give low results.

Potassium Permanganate Test.

18. To 100 ml. of acetone contained in a 250-ml. Erlenmeyer flask and maintained at 25° C., 1 ml. of 0.1-per-cent potassium permanganate solution shall be added with slight stirring.

TENTATIVE METHODS OF TESTING NITROCELLULOSE CLEAR LACQUERS AND LACQUER ENAMELS[1]

A.S.T.M. Designation: D 333 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Weight per Gallon.

1. (*a*) The weight in pounds per U. S. gallon shall be obtained by multiplying the specific gravity by 8.33. The specific gravity shall be determined by any convenient method that is accurate to the second decimal place, the temperature of both sample and water being 20° C.

(*b*) *Mobile Liquids.*—For sufficiently mobile liquids a convenient apparatus is an accurately calibrated volumetric flask. Fill to the mark at 20° C. and weigh accurately. Apply the following equation:

$$\text{Sp. gr.} = \frac{\text{Weight in grams of contents}}{\text{Capacity in milliliters}}$$

(*c*) *Viscous Materials.*—For very viscous materials which cannot be conveniently introduced into a volumetric flask, any convenient vessel of known capacity may be used. A suitable apparatus is described in the Standard Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches (A.S.T.M. Designation: D 70) of the American Society for Testing Materials.[2]

Drying Time.

2. The sample and a mutually agreed upon standard shall be flowed without thinning, crosswise on a clean 4 by 8-in. glass plate and examined for drying and hardening at specified periods such as 3 minutes, 15 minutes, 1 hour, and 24 hours. The drying shall be judged by touching or pressing the films with the finger at approximately the same points.

Color.

3. A panel for the color test shall be prepared by pouring the sample and a mutually agreed upon standard on an opaque surface in such a manner that the two materials shall flow together along

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. P. H. Cathcart, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 664.

adjacent edges. The background shall be a mutually agreed upon material. A preliminary examination may be made after 1 hour, but the final examination shall not be made until 24 hours after pouring.

Gloss. 4. The panel prepared for the color test in accordance with Section 3 shall be examined after 24 hours for gloss. A convenient method of determining apparent gloss is to hold the test panel at an angle of incidence approaching 180 deg. to a source of artificial light and to note the comparative sharpness of the definition of the image (for example, the lamp filament).

Homogeneity. 5. The sample shall be thinned with the thinner recommended, in the proportions recommended. The thinned sample shall be flowed on a glass panel and dried in a dust-free atmosphere. The panel shall be examined by reflected and transmitted light for pigment dispersion and freedom from particles of foreign matter.

Print Test. 6. The test panel for the print test shall be prepared in a manner mutually agreed upon by the buyer and seller. The test panel shall be covered with two pieces of ordinary cheesecloth over which shall be placed a piece of felt about $\frac{3}{32}$ in. in thickness. A known uniform pressure shall then be applied to the felt, over a circular area of at least 1 in. in diameter for a given length of time. The time allowed for the lacquer to dry before applying the pressure shall be also predetermined.

Tests shall be made under definite, predetermined conditions of temperature and humidity or, if this is not possible, a standard shall be run at the same time.

Bending Test. 7. The composition of the metal test panel for the bending test, the gage thereof and the manner of application of lacquer coating applied thereto, shall be mutually agreed upon by the buyer and seller.

The test shall be made by bending the panel at a uniform rate through an angle of more than 140 deg. over a mandrel of mutually agreed upon radius.

Outdoor Exposure. 8. At least two test panels shall be exposed outdoors on an exposure rack, in full sunlight, at an angle of 45 deg. from the vertical facing south, and examined at regular intervals for color, gloss, etc., and compared with a standard panel prepared and exposed in a manner mutually agreed upon by the buyer and seller.

TENTATIVE METHOD OF TEST
FOR
VAPOR PRESSURE OF NATURAL GASOLINE (REID METHOD)[1]

A.S.T.M. Designation: D 323 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1930; REVISED, 1931.

Scope. 1. This method is intended for the determination of the vapor pressure of natural gasoline.

APPARATUS

Vapor-Pressure Bomb. 2. The vapor-pressure bomb consisting of two sections or chambers, an upper section or air chamber and a lower section or gasoline chamber, shall conform to the following requirements:

(*a*) *Air Chamber.*—The upper section or air chamber, shall be a cylindrical vessel 2 to $2\frac{1}{8}$ in. in diameter and 10 in. $\pm \frac{1}{8}$ in. in length, inside dimensions. In one end of the air chamber a $\frac{1}{4}$-in. pipe thread shall be tapped, to receive the gage coupling, shown in Fig. 1. Other means of connecting the air chamber with the pressure gage may be employed, provided the requirements of Paragraphs (*d*) and (*e*) are fulfilled. In the other end of the air chamber an opening approximately $\frac{1}{2}$ in. in diameter shall be provided for purposes of coupling with the gasoline bomb. The nature of this opening will depend upon the method of coupling employed. The air chamber must drain completely from either end when held in a vertical position and for this reason the ends may be slightly convex.

(*b*) *Gasoline Chamber for Sampling Materials at Atmospheric Pressure.*—The lower section or gasoline chamber, shown in Fig. 1 (*a*), shall be a cylindrical vessel of the same inside diameter as the air chamber and $2\frac{1}{2}$ in. $\pm \frac{1}{16}$ in. in inside length. In one end of the gasoline chamber an opening approximately $\frac{1}{2}$ in. in diameter shall be provided for purposes of coupling with the air chamber. The nature of this opening will depend upon the method of coupling employed. The other end of the gasoline chamber shall be completely closed. The gasoline chamber must drain completely when inverted and for this reason the top may be slightly convex.

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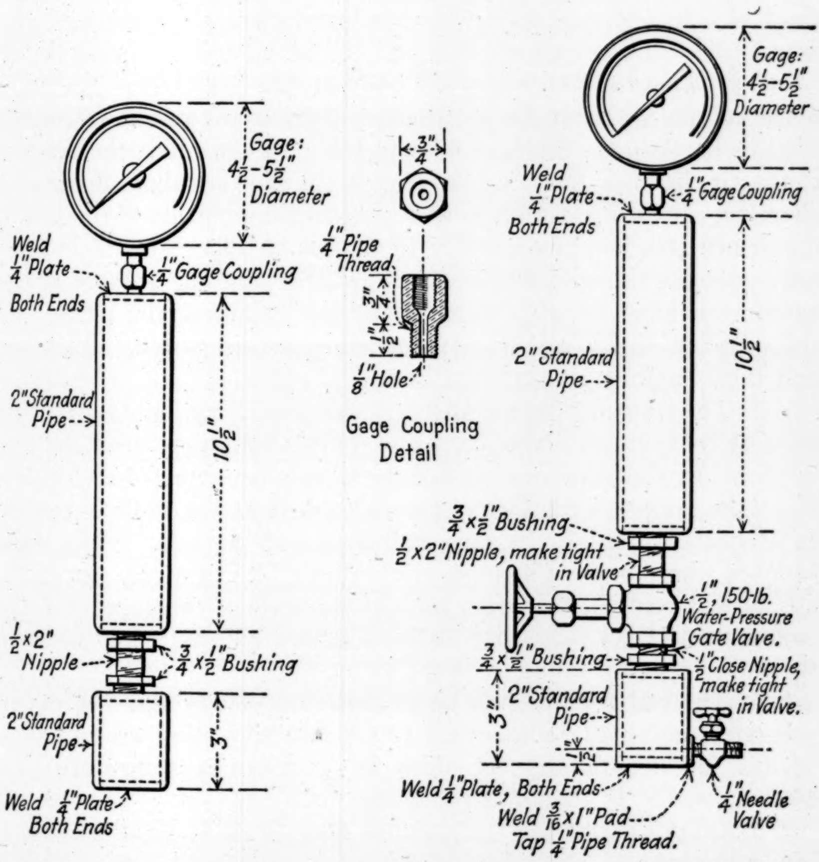
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

This method is essentially the same as that contained in the Interstate Commerce Commission Regulations for the Transportation of Explosives and Other Dangerous Articles by Freight and Express and in Baggage Service.


Gage: $4\frac{1}{2}$-$5\frac{1}{2}$" Diameter
Weld $\frac{1}{4}$" Plate Both Ends
$\frac{1}{4}$" Gage Coupling
2" Standard Pipe
$10\frac{1}{2}$"
$\frac{1}{2}$×2" Nipple
$\frac{3}{4}$×$\frac{1}{2}$" Bushing
2" Standard Pipe
3"
Weld $\frac{1}{4}$" Plate Both Ends
$\frac{3}{4}$"
$\frac{1}{4}$" Pipe Thread
$\frac{3}{4}$"
$\frac{1}{2}$"
$\frac{1}{8}$" Hole
Gage Coupling Detail
Gage: $4\frac{1}{2}$-$5\frac{1}{2}$" Diameter
Weld $\frac{1}{4}$" Plate Both Ends
$\frac{1}{4}$" Gage Coupling
2" Standard Pipe
$10\frac{1}{2}$"
$\frac{3}{4}$×$\frac{1}{2}$" Bushing
$\frac{1}{2}$×2" Nipple, make tight in Valve
$\frac{1}{2}$", 150-lb. Water-Pressure Gate Valve.
$\frac{3}{4}$×$\frac{1}{2}$" Bushing
$\frac{1}{2}$" Close Nipple, make tight in Valve.
2" Standard Pipe
3"
$\frac{1}{4}$
Weld $\frac{1}{4}$" Plate, Both Ends
Weld $\frac{3}{16}$×1" Pad Tap $\frac{1}{4}$" Pipe Thread.
$\frac{1}{4}$" Needle Valve

(a) For Sampling by Immersion. (b) For Sampling Under Pressure.

FIG. 1.—Vapor Pressure Bomb.

(c) *Gasoline Chamber for Sampling Materials Under Pressure.*—For testing natural gasoline where it is impracticable to obtain a sample by immersing the gasoline chamber in the liquid, as for example, gasoline in pressure storage or gasoline being transported by pipe line, the gasoline chamber shall conform to the requirements specified in Paragraph (*b*) except that a $\frac{1}{4}$-in. needle valve shall be attached near the bottom and a $\frac{1}{2}$-in. gate valve shall be introduced in the coupling between the chambers as illustrated in. Fig. 1 (*b*).

(*d*) *Method of Coupling Air and Gasoline Chambers.*—Any method of coupling the air and gasoline chambers may be employed, for example, a simple screw union or a clamp. The sole provision in this respect is that the assembly shall be free from leaks under the conditions of test. Responsibility for freedom from leaks rests with the user.

(*e*) *Volumetric Capacity of Air and Gasoline Chambers.*—The ratio of the volume of the air chamber to the volume of the gasoline chamber shall be between the limits of 3.8 and 4.2. To determine the volume of the air chamber, insert a $\frac{1}{4}$-in. plug in the gage coupling, invert the chamber, fill with water up to and including the portion of the coupling device attached permanently to the air chamber and then carefully measure the volume of water. To determine the volume of the gasoline chamber fill with water up to and including the portion of the coupling device attached permanently to the gasoline chamber, and then carefully measure the volume of water.

Pressure Gage.

3. The pressure gage shall be a standard Bourdon type spring gage $4\frac{1}{2}$ to $5\frac{1}{2}$ in. in diameter. The range of the gage used shall be governed by the vapor pressure of the sample being tested, as follows: For those samples with a vapor pressure not in excess of 12 lb. per sq. in. absolute at 100° F. the gage shall have a 15-lb. scale. For those samples whose vapor pressures are between 12 and 45 lb. per sq. in. absolute at 100° F., the upper limit of the scale of the gage shall not be less than 45 nor more than 60 lb. Gages shall be checked frequently and adjusted if found in error.

Water Bath.

4. The water bath shall be of such dimensions that the vapor-pressure bomb may be immersed to the bottom of the pressure gage. Means for maintaining the bath at a constant temperature of 100° F ± 0.5° F. should be provided.

Connections.

5. (*a*) All permanent connections may be made tight by soldering or tinning.

(*b*) Special threads or other suitable means may be used in making the connection between the two chambers in order to obtain a tight connection without the use of a wrench.

PROCEDURE

Filling the Gasoline Chamber.

6. (*a*) *Sampling Tank Cars and Open Tanks.*—The empty gasoline chamber, Fig. 1 (*a*), shall first be immersed in the tank or container of the liquid to be tested and allowed to fill while being raised and lowered through the liquid. This first filling is for the purpose

of thoroughly washing the chamber, which should then be emptied. The chamber shall then be refilled in the same manner, care being exercised to see that it is completely filled with the liquid.

(*b*) *Sampling Systems Under Pressure.*—The gasoline chamber equipped with valves, top and bottom, Fig. 1(*b*), shall be used.

Before drawing the sample, the liquid section of the gasoline chamber shall be cooled to a temperature as low as or lower than that of the gasoline to be tested. The sample shall be taken as follows:

Close both valves and connect the gasoline chamber to the tank, pipe line, or other receptacle holding the liquid to be tested, by means of the lower valve of the chamber. The sample must be taken at a place which will ensure that a representative sample of the gasoline is being obtained.

TABLE I.—TEMPERATURES TO WHICH GASOLINE AND GASOLINE CHAMBER SHALL BE COOLED BEFORE POURING SAMPLE.

APPROXIMATE VAPOR PRESSURE OF SAMPLE, LB.	TEMPERATURE OF SAMPLE AND CHAMBER WHEN POURING, DEG. FAHR. ± 5° F.
9 (or under)	50
12	40
16	30
20	25
25	20
30	15

With the upper valve closed, open the valve on the tank or pipe line and then open the lower valve on the gasoline chamber, allowing full tank or line pressure to be exerted on the chamber. Open slightly the upper valve of the chamber and allow gasoline to escape until a volume equal to at least twice the capacity of the gasoline chamber shall have been displaced. This procedure insures the removal of all air from the chamber. The operation of purging should be accomplished without allowing the pressure in the chamber to drop below that of the tank or line. After filling the gasoline chamber, close both top and bottom valves in the order mentioned, and disconnect the chamber from the tank or pipe line. After disconnecting the gasoline chamber, attach it to the air chamber immediately; and immediately open the upper valve of the gasoline chamber. If the air chamber is not immediately attached, the gasoline chamber should be kept chilled to prevent rupturing due to expansion of its contents.

(*c*) *Sampling by Pouring.*—A sample shall not be transferred to the gasoline chamber by pouring unless it is impossible to obtain it by either of the methods described in Paragraphs (*a*) and (*b*). When this is the case both the liquid and the gasoline chamber shall be cold enough so that no appreciable change in composition of the sample occurs during the pouring. Table I gives the maximum pouring temperatures for gasolines of various vapor pressures. The responsibility for errors incurred by pouring rests solely with the operator. Pouring shall not be used in referee tests.

(*d*) *Sampling by Water Displacement.*—It is recommended that transfer by water displacement be used when the methods described in Paragraphs (*a*), (*b*) and (*c*) cannot be employed.

Procedure. 7. Prior to each test the air chamber, from which the gage has been removed, shall be thoroughly purged of any gasoline vapors that may remain from a previous test. The purging may best be accomplished by filling the air chamber with warm water (90 to 100° F.) and allowing it to drain. This operation shall be repeated at least five times. If the air chamber is purged some time before the test is made, it should be rinsed with water (temperature optional) just before the test is started. Prior to each test, the gage should be shaken to dislodge gasoline that may remain from a previous test. The gage shall then be attached to the air chamber.

The temperature of the air and water vapor in the air chamber shall be determined by inserting a thermometer of suitable range and accuracy inside the chamber just before making the connection with the gasoline chamber. The thermometer shall be allowed to remain in the air chamber for not less than 5 minutes before the temperature is read. This temperature reading shall be recorded as the "initial air temperature." It is necessary that the initial air temperature shall be the actual temperature of the air in the air chamber when attached to the gasoline chamber. Immediately, after determining the initial air temperature, the air chamber with gage in place shall be attached tightly to the gasoline chamber containing the sample to be tested (see Section 6). If a threaded coupling is employed, a little shellac or other suitable sealing material on the threads may assist in making a tight connection.

The vapor-pressure bomb shall then be turned upside down and shaken vigorously in this position. This operation should be repeated several times. The bomb shall then be immersed at least up to the bottom of the pressure gage in the water bath, which shall be held at a constant temperature of 100° F. ± 0.5° F. While the bomb is immersed in the bath, the apparatus shall be closely observed for leaks. The coupling device is normally in the liquid section of the apparatus and because it is most in use, shall be given particular attention. Liquid leaks are more difficult to detect than vapor leaks. If a leak is detected the test shall be discarded. After 5 minutes the bomb shall be withdrawn from the bath, inverted, shaken vigorously and replaced in the bath. Thereafter, at intervals of two minutes, the bomb shall be withdrawn from the bath, inverted, shaken vigorously and replaced in the bath. These operations shall be done quickly to avoid cooling the bomb and its contents.

Prior to each removal of the bomb from the bath, the gage reading shall be observed. The gage should be tapped lightly prior to each reading. The temperature of the bath shall also be closely observed to make certain that it is within the specified limits. When consecutive gage readings thus observed become constant the value of the reading shall be recorded as the "uncorrected vapor pressure" of the sample under test.

TABLE II.—CORRECTIONS TO CONVERT UNCORRECTED VAPOR PRESSURES TO REID VAPOR PRESSURES.

$$\text{Correction factor} = \frac{(14.4 - P_t)\,(t - 100)}{460 + t} - (P_{100} - P_t)$$

where t = the air chamber temperature at beginning of test, deg. Fahr.
P_t = the vapor pressure of water, lb. per sq. in., at t° F.
P_{100} = the vapor pressure of water, lb. per sq. in., at 100° F.
14.4 = the atmospheric pressure in lb. per sq. in.

INITIAL AIR TEMPERATURE, DEG. FAHR.	CORRECTION LB.	INITIAL AIR TEMPERATURE, DEG. FAHR.	CORRECTION, LB.	INITIAL AIR TEMPERATURE, DEG. FAHR.	CORRECTION, LB.
32	−2.9	60	−1.8	86	−0.7
34	−2.8	62	−1.8	88	−0.6
36	−2.7	64	−1.7	90	−0.5
38	−2.7	66	−1.6	92	−0.4
40	−2.6	68	−1.5	94	−0.3
42	−2.5	70	−1.4	96	−0.2
44	−2.5	72	−1.3	98	−0.1
46	−2.4	74	−1.3	100	0.0
48	−2.3	76	−1.2	102	+0.1
50	−2.2	78	−1.1	104	+0.2
52	−2.1	80	−1.0	106	+0.3
54	−2.0	82	−0.9	108	+0.5
56	−2.0	84	−0.8	110	+0.6
58	−1.9				

8. To calculate the "Reid vapor pressure" of the sample under test, the "uncorrected vapor pressure" must be corrected for the **Calculations.**

change in the pressure of the water vapor and air in the air chamber due to the differences between the "initial air temperature" and the temperature of the bath. Table II shows the corrections to apply for "initial air temperatures" ranging from 32° F. to 110° F. This corrected value shall be recorded as the "Reid vapor pressure."

NOTE.—*Example:* If the initial air temperature is 82° F. and the uncorrected vapor pressure is 24.6 lb., the Reid vapor pressure is 24. 6 lb. minus 0.9 lb. or 23.7 lb.

Due to the fact that the atmospheric pressure provided in the air chamber counteracts the external atmospheric pressure, the only pressure acting internally on the pressure gage is the absolute vapor pressure of the liquid in the bomb so that the gage reading is the absolute vapor pressure of the liquid in pounds per square inch at 100° F. For purposes of brevity the "Reid vapor pressure" shall be recorded in pounds, without reference to temperature used in the test or to unit of surface.

Accuracy. 9. With proper care and attention to detail, duplicate results obtained for Reid vapor pressure values should not differ from each other by more than 0.5 lb.

TENTATIVE DEFINITIONS OF TERMS RELATING TO PETROLEUM[1]

A.S.T.M. Designation: D 288 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1931.

Crude Petroleum.—A naturally occurring mixture, consisting predominantly of hydrocarbons, and/or of sulfur, nitrogen and/or oxygen derivatives of hydrocarbons, which is removed from the earth in liquid state or is capable of being so removed.

NOTE.—Crude petroleum is commonly accompanied by varying quantities of extraneous substances such as water, inorganic matter and gas. The removal of such extraneous substances alone does not change the status of the mixture as crude petroleum. If such removal appreciably affects the composition of the oil mixture, then the resulting product is no longer crude petroleum.

Topped Crude Petroleum.—A residual product remaining after the removal, by distillation, or other artificial means, of an appreciable quantity of the more volatile components of crude petroleum.

Weathered Crude Petroleum.—The product resulting from crude petroleum through loss, due to natural causes, during storage and handling, of an appreciable quantity of the more volatile components.

Benzine.—This term is archaic and misleading and should not be used.

Petroleum Naphtha.—A generic term applied to refined, partly refined or unrefined petroleum products and liquid products of natural gas, not less than 10 per cent of which distills below 347° F. (175° C.) and not less than 95 per cent of which distills below 464° F. (240° C.), when subjected to distillation in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.

NOTE.—The "naphthas" used for specific purposes such as cleaning, manufacture of rubber, manufacture of paints and varnishes, etc., are made to conform to specifications which may require products of considerably greater volatility than that set by the limits of this generic definition.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

Gasoline.—A refined petroleum naphtha which by its composition is suitable for use as a carburant in internal combustion engines.

Petroleum Spirits (White Spirits).—A refined petroleum distillate with a minimum flash point of 70° F. (21° C.) determined by the Tag Closed Tester in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids (A.S.T.M. Designation: D 56) of the American Society for Testing Materials or by the Abel Tester, with volatility and other properties making it suitable as a thinner and solvent in paints, varnishes and similar products.

NOTE.—The term "turpentine substitute" as applied to petroleum spirits is to be condemned as false and misleading. The term "mineral spirits" which is frequently used in the paint and varnish industry is a misnomer as it includes within its scope not only petroleum products, but other hydrocarbon mixtures, such as coal-tar distillates. In Great Britain the term "petroleum spirits" is applied to a very light hydrocarbon mixture having a flash point below 32° F. (0° C.).

Kerosine.—A refined petroleum distillate having a flash point not below 73° F. (23° C.), as determined by the Abel Tester (which is approximately equivalent to 73° F. (23° C.) as determined by the Tag Closed Tester, A.S.T.M. Standard Method D 56) and suitable for use as an illuminant when burned in a wick lamp.

NOTE.—In the United States of America local ordinances or insurance regulations require flash points higher than 73° F. (23° C.), Tag Closed Tester.

Gas Oil.—A liquid petroleum distillate having a viscosity intermediate between that of kerosine and lubricating oil.

NOTE.—It should be understood that oils, other than gas oil as defined above, may be and are used in the manufacture of gas.

Fuel Oil.—Any liquid or liquefiable petroleum product burned for the generation of heat in an industrial or household furnace or firebox, or for the generation of power in a diesel engine, exclusive of oils with a flash point below 100° F., Tag closed tester, and oils burned in cotton or wool-wick burners. Fuel oils in common use fall into one of four classes: (1) residual fuel oils, which are topped crude petroleums or viscous residuums obtained in refinery operations; (2) distillate fuel oils, which are distillates derived directly or indirectly from crude petroleum; (3) crude petroleums and weathered crude petroleums of relatively low commercial value; (4) blended fuels, which are mixtures of two or more of the three preceding classes.

Tar, Pitch.—These terms shall not be applied to petroleum products.

Petroleum Lubricating Grease.—A combination of a petroleum product and a soap or a mixture of soaps, suitable for certain types of lubrication.

Oil-Shale.—A compact rock of sedimentary origin, with an ash content of more than 33 per cent and containing organic matter that yields oil when destructively distilled but not appreciably when extracted with the ordinary solvents for petroleum.

Crude Shale Oil.—The oil obtained as a distillate by the destructive distillation of oil-shale.

End Point.—The highest temperature reading observed on the distillation thermometer during the distillation procedure conducted in accordance with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.

Engine Distillate.—A refined or unrefined petroleum distillate similar to naphtha, but often of higher distillation range.

Tops.—The unrefined distillate obtained in topping a crude petroleum.

TENTATIVE METHODS OF TESTING ASPHALT ROLL-ROOFING SURFACED WITH FINE TALC, GRANULAR TALC, OR MINERAL GRANULES; ALSO ASPHALT SHINGLES SURFACED WITH MINERAL GRANULES[1]

A.S.T.M. Designation: D 228 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED AS TENTATIVE, 1925; ADOPTED, 1927; REISSUED AS TENTATIVE, 1930; REVISED, 1931.

Scope. 1. These methods cover the examination of roofings and shingles composed of roofing-felt, saturated and coated on both sides with asphalt, and surfaced on the top with either powdered or granulated mineral matter, and on the under side with powdered mineral matter.

Types of Roofing and Shingles. 2. Asphalt roll-roofings and shingles may be divided into two types, as follows (see Fig. 1):

Type X.—A layer of felt saturated and coated with bituminous matter having the surface coatings dusted with fine mineral matter (for example, talc). This type embraces what is commercially known as "smooth-surfaced roll-roofing."

Type Y.—This type is similar to Type X, but with a top surfacing of either (1) coarse mineral matter (for example, granular slate) embracing what is commercially known as "mineral-surfaced roll-roofing" and "mineral-surfaced shingles;" or (2) moderately coarse mineral matter (for example, granular talc) embracing what is commercially known as "roll-roofing surfaced with granular talc."

SAMPLING

Sampling. 3. From each shipment or portion thereof representing a product of the same kind, class, and weight, a number of rolls or bundles shall be selected at random, equivalent to one-half the cube root of the total number of rolls or bundles included in the lot, except that in lots of 1000 or less, five rolls or bundles shall be taken. If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the nearest higher whole number. For convenience, the following table is given, showing the number of samples to be selected from shipments of various sizes.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 801 Second Ave., New York City.

PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED	PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED
Up to 1000	5	5 833 to 8 000	10
1001 to 1728	6	8 001 to 10 648	11
1729 to 2744	7	10 649 to 13 824	12
2745 to 4096	8	13 825 to 17 576	13
4097 to 5832	9	17 577 to 21 952	14

DETERMINATION OF SIZE AND WEIGHT

(*A*) *Smooth-roll and Mineral-Surfaced Roll-Roofing*

Packing Material, Nails and Cement.

4. Each roll selected shall be weighed to the nearest $\frac{1}{4}$ lb. The wrappers, packing material, nails, and cement from each roll shall be weighed together to the nearest $\frac{1}{4}$ lb. and the average weight thereof per "square" shall be recorded. The quantity and character of nails and cement shall be recorded.

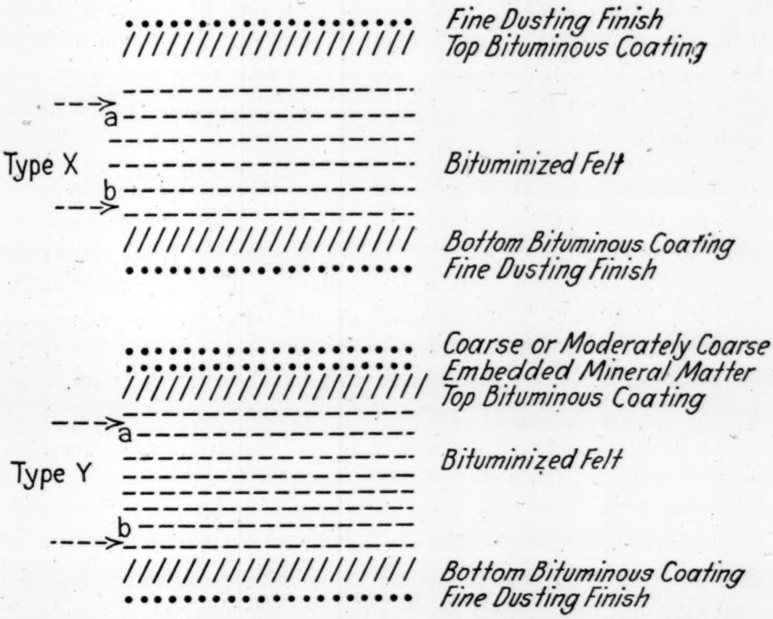
Fine Dusting Finish
Top Bituminous Coating
a
Type X
Bituminized Felt
b
Bottom Bituminous Coating
Fine Dusting Finish
Coarse or Moderately Coarse
Embedded Mineral Matter
Top Bituminous Coating
a
Type Y
Bituminized Felt
b
Bottom Bituminous Coating
Fine Dusting Finish

FIG. 1.—Construction of Two Types of Asphalt Roll-Roofing and Shingles.

Weight of Loose Surfacing.

5. Each roll shall be unwound and the workmanship and finish of the roofing observed. Record the weight of any loose surfacing that may fall off in so doing.

Area.

6. The length and width of each roll shall be measured to the nearest $\frac{1}{4}$-in., and the square feet of material contained in each roll shall be calculated. From these values, the average area of the rolls examined shall be calculated.

Minimum Weight per 108 sq. ft. 7. From the above the net weight, exclusive of loose surfacing, of roofing per 108 sq. ft. contained in each roll shall be calculated and the minimum weight per 108 sq. ft. recorded. This shall be regarded as the minimum weight per 108 sq. ft. of the lot.

Average Weight per 108 sq. ft. 8. The average weight per 108 sq. ft. for the rolls examined shall be calculated. This shall be regarded as the average weight per 108 sq. ft. of the lot.

Selecting Average Weight Rolls. 9. From the rolls examined, the one whose weight per 108 sq. ft. is nearest the average weight of the lot shall be selected. The first convolution or two shall be unrolled, and with a knife and straight edge, the sheet shall be cut across at right angles to the edges. A section measuring exactly 30-in. in the direction of the roll's length shall then be removed. The width of this section shall be measured to the nearest $\frac{1}{32}$-in. and weighed, neglecting any loose surfacing. The weight in pounds per 108 sq. ft. shall then be calculated from the following formula:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of 30-in. section in ounces}}{\text{Width of 30-in. section in inches}} \times 32.4$$

The weight so determined shall check within 1.5 per cent, the average weight per 108 sq. ft. of the lot (Section 8). If this sample fails to check, then additional samples shall be cut from the same roll, until one is obtained which does and this sample shall be kept for further examination as described in Sections 19 to 25.

NOTE.—As a referee method, or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, a 30-in. sample shall be taken and examined separately from each roll sampled in Section 3.

(*B*) *Shingles Surfaced with Mineral Granules*

Weight of Packing Material. 10. Each bundle selected shall be weighed to the nearest $\frac{1}{4}$ lb. The packing materials shall be weighed to the nearest $\frac{1}{4}$ lb. and the weight recorded separately for each bundle. The average weight of packing material per "square" shall be recorded.

Weight of Loose Surfacing. 11. The shingles in each bundle, a, shall be counted and the workmanship and finish of the shingles shall be observed. Record the weight of any loose surfacing that may fall off in so doing.

Net Weight and Area. 12. From the above the net weight of each bundle, exclusive of loose surfacing, shall be calculated, b. The dimensions of two representative shingles shall be accurately measured and the net area of material in each shingle calculated in square feet, c.

Minimum Weight per 108 sq. ft. 13. The area in square feet of material contained in each bundle ($a \times c$) shall be calculated. The net weight of roofing material per

108 sq. ft. contained in each bundle $\left(\frac{b}{a \times c} \times 108\right)$ shall be calculated, and the minimum weight per 108 sq. ft. recorded. This shall be regarded as the minimum weight per 108 sq. ft. of the lot.

Average Weight per 108 sq. ft.

14. The average weight, *d*, per 108 sq. ft. for the bundles examined shall be calculated. This shall be regarded as the average weight per 108 sq. ft. of the entire shipment.

The average weight per shingle $\left(\frac{c \times d}{108}\right)$ shall be calculated.

Selecting Average Weight Shingles.

15. From the bundles selected, a definite number of representative shingles whose weight per 108 sq. ft. shall fall within 1.5 per cent of the average weight ascertained in Section 14 shall be taken for further examination in accordance with Sections 19 to 25. The number of shingles so selected shall represent as closely as possible 6 sq. ft. of material, and shall be selected as far as possible from different bundles.

NOTE.—As a referee method, or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, then a similar sample shall be taken from each bundle of shingles selected in accordance with Section 3 and examined separately.

DETERMINATION OF PLIABILITY OF SMOOTH ROLL-ROOFING AND MINERAL-SURFACED ROLL-ROOFING

Pliability.

16. With a photographic trimmer, ten strips shall be cut from a sample of roofing, each 1 in. in width and 8 in. in length, five strips in the direction of the fiber grain, and five across the grain. These strips shall be immersed in water at 77° F. (25° C.) for 10 to 15 minutes, after which they shall be removed from the water and immediately bent through an angle of 90 deg. over a rounded corner of ½ in. radius in exactly two seconds without exerting any strain upon the test strip other than that required to keep it in contact with the rounded corner and to avoid kinking.

A block of wood 3 in. square by 2 in. thick with rounded corners of the dimension specified shall be used in making this test.

The strips of roofing, exposure side up, shall be held by hand tight against the upper 2-in. face of the block. The projecting end of the strip shall then be bent over the rounded corner of specified radius with the other hand.

Surface ruptures aggregating more than ⅛ in. in length in any direction shall be considered a crack.

DETERMINATION OF BEHAVIOR ON HEATING

Behavior on Heating. 17. Two strips shall be cut from the sample of roofing or shingles, each approximately 8 by 8 in. They shall be weighed and then suspended vertically, in the same direction as the material would be applied to the roof, in the center of an air-oven maintained at 176° F. ± 5° F. (80° C. ± 3° C.) by means of a thin wire fastened through holes punctured near one edge. The internal dimensions of the oven shall not be less than 12 by 12 by 12-in. An electrically-heated oven is recommended. The thermometer shall be inserted in the oven to such a depth that its bulb will be in line with the center of the specimens. The strips shall be maintained at the prescribed temperature for exactly two hours, then cooled, in a desiccator, and each specimen weighed. The average loss shall be calculated as a percentage. Any change in appearance of the specimen shall be recorded, such as flowing, sagging, blistering, or absorption of the coatings; also sliding of granular surfacing.

SEPARATION OF THE ROOFING OR SHINGLES INTO THEIR COMPONENT PARTS

Composition. 18. The mineral matter, bituminous matter and fibrous matter may be distributed in the following manner:

A. *Mineral Matter*

I. Detached............. II. Embedded in the top coating............. III. Embedded in the bottom coating.............	*Fine Mineral Matter* (for example, finely ground talc or mica), Type X (on top and bottom); also Type Y (on bottom only). *Moderately Coarse Mineral Matter* (for example, coarsely ground talc), Type Y (on top only). *Coarse Mineral Matter* (for example, crushed slate, crushed brick or tile) Type Y (on top only).
IV. Admixed with the top coating (Types X and Y).................. V. Admixed with the bottom coating (Types X and Y).............	May or may not be present. If present, consists of very fine mineral matter (for example, clay, silica, limestone, slate flour, shale, etc.).

VI. Ash present in desaturated felt (that is, ash on incineration).

B. *Bituminous Matter*

I—Contained in the top coating.
II—Contained in the bottom coating.
III—Saturant of the felt.

C. *Fibrous Matter*

I—The desaturated felt.

Test Strips for Separation of Roofing and Shingles.

19. The test strips for the separation of prepared roofing and shingles into their component parts shall be prepared as follows:

From the samples representing the average weight obtained in Sections 9 and 15 a number of strips shall be cut, each measuring approximately 2-in. in width by 8 in. in length. These shall be weighed, the length and width measured to within 1 mm. or $\frac{1}{32}$ in., and the weight calculated per 108 sq. ft. Any of the 2 by 8-in. strips whose weight varies more than 1.5 per cent from the average weight of the shipment as determined in Sections 8 and 14, shall be rejected, and the remaining strips shall be retained for further examination.

NOTE.—If a strip is cut to exactly 2 by 7.46 in. its weight in grams divided by two gives directly the weight in pounds per 108 sq. ft.

Moisture-Free Felt (C-I).

20. Eight of the 2 by 8-in. strips shall be extracted with benzol, chloroform, or carbon disulfide in a suitable extractor or centrifuge, and the extraction continued until the drippings have become colorless. The desaturated felt shall be removed from the extractor, being careful not to lose any adhering mineral matter, placed in a tared weighing bottle provided with a ground-glass stopper, heated in a ventilated oven at 225° F. ± 5° F. (107° C. ± 3° C.) for 30 minutes, the stopper inserted, then cooled and weighed. The heating shall be repeated until the weight of the felt remains constant as determined by two consecutive weighings taken not less than 10 minutes apart, which shall show a further loss of not more than 0.1 per cent. Any adhering mineral matter shall be brushed off the felt, weighed and retained for further examination. The weight of said adhering mineral matter shall be deducted to obtain the weight of the moisture-free felt. Total mineral matter obtained shall be weighed and recorded for check of later tests. From the weights so obtained and the respective areas of the strips of desaturated felt, the weight of moisture-free felt shall be computed in pounds per 108 sq. ft., from the following formulas and the results averaged:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of moisture-free felt in grams}}{\text{Area of the strips in square centimeters}} \times 221.2$$

or

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of moisture-free felt in grams}}{\text{Area of the strips in square inches}} \times 34.3$$

NOTE.—The desaturated felt may be examined to determine the percentage of various fibers contained therein by the Tentative Methods of Analysis of Roofing Felt for Fiber Composition (A.S.T.M. Designation: D 272 - 29 T) of the American Society for Testing Materials.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 724 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 584.

Ash in Moisture-Free Felt (A-VI).

21. The desaturated felt obtained as described in Section 20 shall be cut into squares about 2 cm. on each side and thoroughly mixed. Pieces amounting to about 10 g. shall be taken at random and dried at 225° F. (107° C.) for 30 minutes. They shall be cooled in a desiccator, accurately weighed and then incinerated in a weighed crucible either over an open flame or in a muffle until all the carbon has been consumed, and weighed. The percentage of ash shall be calculated on the basis of the moisture-free felt.

Bituminous Saturation (B-III) in Moisture-Free Felt.

22. (*a*) From the 2 by 8-in. strips, cut 40 strips about ¾ by 2 in. and weigh, this being a convenient size to handle. These strips shall then be separated into three horizontal sections. The small arrows *a* and *b*, to the left of the various types of roofing illustrated in Fig. 1, indicate approximately where the layers should be separated. The top bituminous coating, with the embedded mineral matter, shall be removed first.

NOTE.—The purpose shall be to remove the entire coatings with some of the saturated felt adhering and no coatings left on the central section of saturated felt. The operator may accomplish this in any way that is most convenient. Care shall be taken to preserve the mineral surfacing with the layers to which it belongs if it becomes detached during the operation.

(*b*) These three horizontal sections thus obtained shall be weighed separately and the total weight should agree within 1 per cent with the original weight of the strips which have been separated. The saturated felt (middle section) shall be extracted with benzol (boiling point 80 to 82° C.) or c.p. carbon disulfide, in a suitable extractor or centrifuge and the extraction continued until the washings have become colorless. The desaturated felt shall be removed from the extractor, placed in a tared weighing bottle, heated until free from moisture and weighed as described in Section 20. Calculate the weight of bituminous saturation by difference. The saturant may be recovered by combining the extract and washings in a 200-ml. distilling flask, provided with a dropping funnel to add the solution during distillation, to which is attached a water-cooled condenser and a receiver, the latter having a vented connection to a vacuum pump. The distilling bulb is immersed in a bath having a temperature of about 212° F. (100° C.) if the solvent were carbon disulfide and a temperature of about 275° F. (135° C.) if benzol or chloroform were used as the solvent. Distillation shall be continued at this temperature at atmospheric pressure until no more solvent is evolved, after which vacuum shall be applied very gradually until a vacuum of 0.5 in. mercury pressure is attained. Great care shall be exercised in applying the vacuum gradually to prevent foaming. This vacuum shall be continued for one hour after the specified vacuum has been reached. The distilling flask shall then be disconnected and the residue represents the felt saturant and shall be weighed.

NOTE.—Use the residue of bituminous saturation recovered from the felt for examining its physical and chemical characteristics.

(*c*) Calculate the percentage of bituminous saturation (*B*–III) carried by the dry felt.

(*d*) Calculate the weight in pounds per 108 sq. ft. of bituminous saturation (*B*–III) present in the dry felt, that is, the weight of moisture-free felt multiplied by the percentage of bituminous saturation (Sections 20 and 22 (c)).

Bituminous Matter in the Top and Bottom Coatings Respectively (B-I and B-II).

23. (*a*) The top and bottom horizontal sections separated from the roofing strips as described in Section 22 shall now be extracted separately with benzol (boiling point 80 to 82° C.) or c.p. carbon disulfide in a suitable extractor or centrifuge and the extraction continued until the washings have become colorless. The insoluble residue from each extraction shall be removed and the pieces of felt picked out and brushed free of adhering mineral matter. The clean pieces of felt shall be placed in a tared weighing bottle, heated until free from moisture and weighed as described in Section 20. The admixed and embedded mineral matter separated from the felt of each extraction shall be dried at 225° F. (107° C.) cooled in a desiccator and weighed. Calculate the weight of bituminous saturant (*B*–III) present in the felt contaminating these top and bottom sections, that is, the felt recovered on extraction multiplied by the percentage of bituminous saturation (Section 22 (*c*)). From the original weight of the top and bottom sections, respectively, subtract the combined weights of dry felt, bituminous saturant and embedded and admixed mineral matter. The difference represents the weight of bituminous matter in the surface coating of that particular section. The percentage of felt in the roofing calculated from the combined weights of felt obtained in each of the three horizontal sections and the original weight of roofing strips taken, should check with the percentage of felt found in Section 20, within 1 per cent. Likewise, the percentage of total mineral matter found in the top and bottom sections should check with the percentage found in Section 20 within 1 per cent. The total percentage of bituminous matter found in these three horizontal sections based on the original weight of strips taken should also agree within 1 per cent with the percentage of total bituminous material calculated

in Section 20, from the difference between the original weight of strips taken and the weight of felt and mineral matter found.

(*b*) Calculate the weight in pounds per 108 sq. ft. of bituminous matter (B–I) in the top coating.

(*c*) Calculate the weight in pounds per 108 sq. ft. of bituminous matter (B–II) in the bottom coating.

(*d*) Calculate the weight in pounds per 108 sq. ft. of total mineral matter embedded and admixed with the top coating.

(*e*) Calculate the weight in pounds per 108 sq. ft. of total mineral matter embedded and admixed with bottom coating.

(*f*) To separate the bituminous constituents in the coatings for further examination and also to check the percentage of mineral matter, both detached and embedded in the top and bottom coatings, with that determined above, the detached mineral matter shall be brushed off from six weighed 2 by 8-in. strips. The strips shall again be weighed and the percentage calculated based on the original weight of strips. The outer portion of the top and bottom surface coatings, respectively, shall then be scraped off after the strips have been heated in an oven at 212° F. (100° C.) for 30 minutes. The coatings shall be scraped off by holding a dull knife at right angles to the strip of roofing supported on a firm level surface and drawing the blade sideways under moderate pressure. Care shall be taken to avoid scraping entirely through the surface coating. This is important. The scrapings shall then be weighed and dissolved in benzol (boiling point 80 to 82° C.) or c.p. carbon disulfide; and the mineral matter separated by filtering or centrifuging and washing with successive portions of solvent. The mineral matter shall then be dried at 225° F. (107° C.), cooled in a desiccator and weighed. Calculate the percentage of mineral matter based on the original weight of roofing strips taken, which should check with that obtained previously. The bituminous matter in the scrapings shall be calculated by difference and reduced to a percentage basis on the original roofing strips used. The bituminous coating shall be recovered by evaporating off the solvent as described under Section 22. Both surface coatings should be treated separately in this manner.

NOTE.—Use the separated bituminous coatings for examining their physical and chemical characteristics.

Coarse and Fine Admixed Mineral Matter.

24. (*a*) *Coarse or Moderately Coarse Embedded Mineral Matter (A–II), also Fine Admixed Mineral Matter (A–IV) in the Top Coating of Type Y.*—The mineral matter recovered from the top sections of Type Y in Section 22 shall be boiled with 100 ml. water and washed through a 65-mesh copper wire screen with sufficient water to remove

the fine material matter. The total aqueous suspension of mineral matter which passes through the screen shall then be recovered by filtering the washings through a weighed Gooch crucible, then dried at 225° F. (107° C.) and reweighed. This approximately represents the fine mineral matter admixed with the top coating. The mineral constituents retained on the 65-mesh screen represent approximately the coarse or moderately coarse mineral matter embedded in the top coating. This shall likewise be dried and weighed.

(*b*) Calculate the weight in pounds per 108 sq. ft. of coarse or moderately coarse mineral matter (*A*–II) embedded in the top coating of Type Y.

(*c*) Calculate the weight in pounds per 108 sq. ft. of fine mineral matter (*A*–IV) admixed with the top coating of Type Y.

Fine Embedded and Admixed Mineral Matter.

25. *Fine Embedded and Admixed Mineral Matter* (*A*–II *and A–IV*) *in the Top Coating of Type X. Likewise Fine Embedded and Admixed Mineral Matter* (*A–III and A–IV*) *in the Bottom Coating of Types X and Y.*—From the data obtained in Sections 23 and 24, calculate the following:

(*a*) The percentage by weight of fine mineral matter admixed with the top coating (Type X);

(*b*) The percentage by weight of fine mineral matter admixed with the bottom coating (Types X and Y);

(*c*) The weight in pounds per 108 sq. ft. of fine mineral matter admixed with the top coating (Type X), that is, the weight of bituminous matter in the top coating multiplied by the percentage by weight of fine mineral matter admixed with the top coating (Sections 23 (*b*) and 25 (*a*)).

(*d*) The weight in pounds per 108 sq. ft. of fine mineral matter admixed with the bottom coating (Types X and Y), that is, the weight of bituminous matter in the bottom coating multiplied by the percentage by weight of fine mineral matter admixed with the bottom coating (Sections 23 (*c*) and 25 (*b*)).

(*e*) The weight in pounds per 108 sq. ft. of fine mineral matter embedded in the top coating (Type X) (Section 23 (*d*)).

(*f*) The weight in pounds per 108 sq. ft. of fine mineral matter embedded in the bottom coating (Types X and Y), that is, the weight of total mineral matter embedded and admixed with the bottom coating minus the weight of fine mineral matter admixed with the bottom coating (Sections 22 (*e*) and 25 (*d*)).

REPORT

Compilation of Results.

26. The following items shall be reported in pounds per 108 sq. ft.:

Items	Type X	Type Y
MINERAL MATTER:		
Fine mineral matter embedded in top coating	Section 25 (*e*)	....
Coarse or moderately coarse mineral matter embedded in top coating	....	Section 24 (*b*)
Fine mineral matter embedded in bottom coating	Section 25 (*f*)	Section 25 (*f*)
Fine mineral matter admixed with top coating	Section 25 (*c*)	Section 24 (*c*)
Fine mineral matter admixed with bottom coating	Section 25 (*d*)	Section 25 (*d*)
BITUMINOUS MATTER:		
Contained in top coating	Section 23 (*b*)	Section 23 (*b*)
Contained in bottom coating	Section 23 (*c*)	Section 23 (*c*)
Saturant of the felt	Section 22	Section 22
FIBROUS MATTER:		
Felt after desaturation	Section 20	Section 20
Net weight of roofing material	Sum	Sum
Average weight per 108 sq. ft. (check total)	Section 8, 9 or 14	Section 8, 9 or 14
Loose mineral surfacing	Section 6 or 11	Section 6 or 11
Packing material, nails and cement	Section 4	Section 3 or 9
Gross weight per 108 sq. ft	Sum	Sum
ASH:		
Percentage from desaturated felt	Section 21	Section 21

If desired, the results may also be expressed as a percentage by weight.

TENTATIVE METHOD OF FLEXURE TESTING OF NATURAL BUILDING STONE[1]

(DETERMINATION OF MODULUS OF RUPTURE)

A.S.T.M. Designation: D 327 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1930; Revised, 1931.[2]

Scope. 1. This method of test is intended for the determination of the modulus of rupture of natural building stones used for exterior or interior construction or decorative purposes.

APPARATUS

Testing Machine. 2. The testing machine shall be sensitive to 5 lb. when loaded to 500 lb.

Knife Edges. 3. For the support of the test specimen a set of knife edges similar to those shown in Fig. 1 shall be provided. The load shall be applied through a third knife edge of the same type.

TEST SPECIMENS

Test Specimens. 4. The sample supplied shall be of sufficient size to provide all of the specimens required for the test. The test specimens shall be sawed from the sample and shall be finished as closely as practicable to 12 by 4 by 1 in. in size either by the use of grinding wheels or by hand rubbing with abrasive powders on steel plates. The 12 by 4-in. faces shall be made as nearly plane and parallel as practicable. No chiseling or other hand cutting shall be permitted.

Types of Specimens. 5. Three or more specimens shall be prepared for each required combination of load application and bedding or rift plane direction, such as are shown in Fig. 2, and noted below:

(*a*) Load applied perpendicular to bedding or rift planes;

(*b*) Load applied parallel to bedding or rift planes;

(*c*) Load applied perpendicular to bedding or rift planes with the bedding or rift planes vertical.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Revision accepted by Committee E-10 on Standards, August 6, 1931.

PROCEDURE

Measurements. 6. The thickness and width of the specimen at the mid-section shall be measured to the nearest 0.01 in.

Conditioning. 7. Before testing, the specimens shall be dried in an oven at a temperature of 110 to 120° C. for 24 hours.

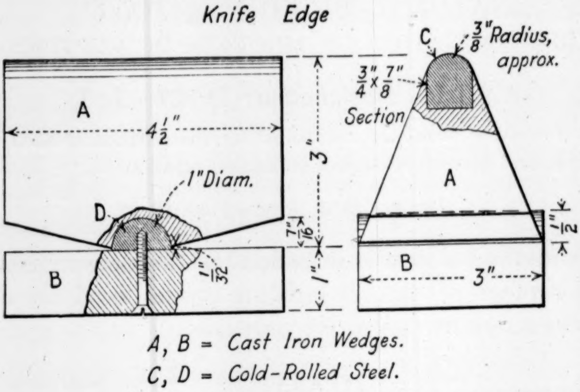
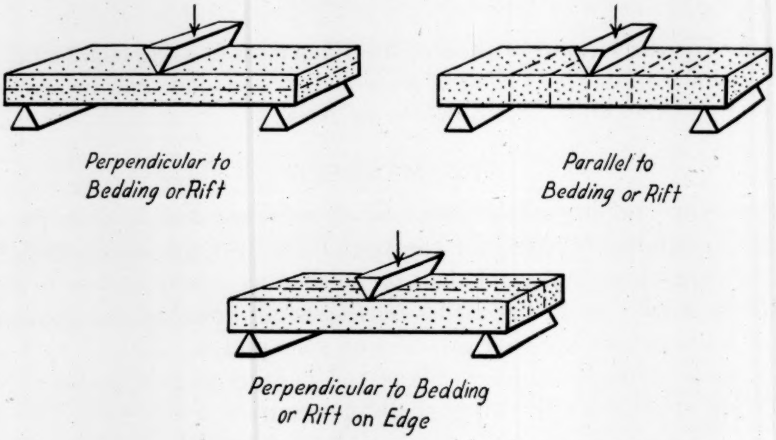

Knife Edge
C
3/8" Radius, approx.
3/4" x 7/8" Section
A
4 1/2"
1" Diam.
D
3"
7/16"
1/32"
B
1"
A
1/2"
B
3"
A, B = Cast Iron Wedges.
C, D = Cold-Rolled Steel.

FIG. 1.—Self-Adjusting Knife-Edge Bearing and Load-Application Device.


Perpendicular to Bedding or Rift

Parallel to Bedding or Rift

Perpendicular to Bedding or Rift on Edge

Dashed lines indicate direction of bedding or rift.
Arrows indicate direction of loading.

FIG. 2.—Methods of Applying Load with Reference to Bedding or Rift.

Procedure. 8. The test specimen shall be supported on the knife edges on 10-in. centers and the load applied at the center of the specimen through the third knife edge (see Fig. 2). The load shall be applied at the rate of 100 lb. per minute. The breaking load shall be recorded to the nearest 5 lb.

Calculation.

9. The modulus of rupture shall be calculated from the formula:

$$R = \frac{3wl}{2bd^2}$$

where R = modulus of rupture;
w = breaking load in pounds;
l = length of span in inches;
b = width of specimen in inches; and
d = thickness of specimen in inches.

Reporting Results.

10. The average value of the modulus obtained from a group of not less than two specimens shall be reported as the modulus of rupture for the condition of loading and direction of bedding or rift used. In case any specimen shows a value 25 per cent lower than the average of its group it shall be examined for defects and if the low value appears to be due to imperfections the average of the other specimens in the group shall be reported as the modulus of rupture of the group. All determinations shall be reported as information.

TENTATIVE METHODS OF TEST FOR ABSORPTION AND APPARENT SPECIFIC GRAVITY OF NATURAL BUILDING STONE[1]

A.S.T.M. Designation: D 328 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1930; Revised, 1931.[2]

Scope. 1. These methods of test are intended for the determination of the absorption by weight or by volume, and for the apparent specific gravity of natural building stones used for exterior or interior construction. The calculation of the dry weight of the stone in pounds per cubic foot may also be made from the results of the apparent specific gravity test.

A. Absorption Test

Test Specimens. 2. Samples shall be supplied of sufficient size to provide not less than three test specimens of some regular form such as a cube, prism, or cylinder whose greatest dimension shall be not more than 3 in. and whose least dimension shall be not less than 2 in. All surfaces of specimens shall be smooth finished. No chisels or other hand tools shall be used in finishing specimens.

Conditioning. 3. The specimens shall be dried in an oven at a temperature between 110 and 120° C. for a period of at least 24 hours.

Weighing. 4. (*a*) After drying, the specimens may be cooled in the room for 30 minutes and then weighed. In cases where the specimens cannot be weighed immediatly after cooling, they shall be placed in a desiccator. The weight shall be determined to the nearest 0.05 g.

(*b*) After the initial weighing, the specimens shall be wholly immersed in distilled water at approximately 20° C. for two weeks. At the end of this period the specimens shall be removed, all faces and edges thoroughly wiped off with a damp cloth and the specimen immediately weighed to the nearest 0.05 g.

Note.—The operator should distinguish between a damp cloth and a wet one. In starting the operation, the towel should be sprinkled lightly. When the surface of the specimen is properly mopped off, it should appear dry.

Calculation. 5. The percentage of absorption shall be calculated from the formula:

$$\text{Percentage of absorption} = \frac{100(B - A)}{A}$$

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Revision accepted by Committee E-10 on Standards, August 6, 1931.

where A = the dry weight of the specimen; and
B = the weight of the specimen after immersion.

Reporting Results.

6. (*a*) In general, the average of all the tests shall be reported as the absorption of the stone. Individual determinations which differ by more than 25 per cent from the average of all the determinations may be disregarded when there is evidence that such results are of uncertain value. The absorption shall then be reported as the average of the remaining determinations, but all determinations shall be reported as information.

(*b*) The absorption value obtained from this test is the percentage absorption by weight. To convert the result to percentage absorption by volume multiply by the value of the apparent specific gravity as determined with the same specimens in accordance with Method B. Apparent Specific Gravity, described in Sections 8 and 9.

Report.

7. The report of the absorption test shall state whether the absorption has been determined according to weight or volume and, if the percentage of volume absorption is reported, there shall also be reported the percentage absorption by weight and the apparent specific gravity.

B. *Apparent Specific Gravity*

Weighing.

8. To obtain the apparent specific gravity the weight of the specimen suspended in water shall be determined immediately after the weighing of the specimen described in Section 4 (*b*) (see Note).

NOTE.—When weighing the specimen suspended in water, various methods of suspending the specimen from the balance beam are in use. Fine silk thread or a cradle of light wire whose weight has been carefully determined may be convenient. The cradle should be of such construction that there will be no possibility of air bubbles forming in it. The water container should be of glass and may be supported on a platform which straddles the balance pan, this method allowing the weighings to be made without detaching the pan.

Calculation.

9. (*a*) Having found the weight of the specimen when suspended in water the apparent specific gravity shall be calculated from the formula:

$$\text{Apparent specific gravity} = \frac{A}{B - C}$$

where A = the dry weight of the specimen;
B = the wet weight of the specimen after immersion; and
C = the weight of the specimen suspended in water.

(*b*) The apparent specific gravity shall be calculated for those specimens whose absorption values are to be averaged as described in Section 7, and the average of the apparent specific gravities so calculated shall be reported as that of the stone.

NOTE.—To determine the weight of the dry stone in pounds per cubic foot, the apparent specific gravity is multiplied by 62.4.

TENTATIVE METHOD OF TEST
FOR
MODULUS OF ELASTICITY OF NATURAL BUILDING STONE[1]

A.S.T.M. Designation: D 338 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. This method of test is intended for the determination of the modulus of elasticity in compression or in flexure of natural building stones used for exterior or interior construction or decorative purposes.

APPARATUS

Testing Machines. 2. (*a*) *Elasticity in Flexure.*—When determining the elasticity in flexure the testing machine and knife edges shall conform to the requirements of Sections 2 and 3 of the Tentative Method of Flexure Testing of Natural Building Stone (D 327 – 31 T) of the American Society for Testing Materials.[3] A suitable deflectometer capable of measuring the deflection of the specimen to 0.0001 in. and of such design that it may be attached to the specimen shall be used. A measuring device of satisfactory type is shown in Fig. 1 (*b*).

(*b*) *Elasticity in Compression.*—For determining the elasticity in compression any form of standard testing machine may be used for the compression test together with a spherical bearing block large enough to entirely cover the specimen, but not greater in diameter than three times the width of the loaded face of the specimen. A compressometer of the averaging type capable of measuring the compression of the specimen to 0.00002 in. shall be used. A measuring device of satisfactory type is shown in Fig. 1 (*a*).

TEST SPECIMENS

Test Specimens. 3. (*a*) Samples shall be representative of the material and shall consist of sections cut from apparently sound material, preferably quarry blocks or slabs. The direction of the bedding planes or rift shall be plainly marked on the sample. The sample shall be of sufficient size to allow the preparation of not less than three specimens having the bedding planes or rift running in the proper direction for the kind of test specified, that is, either parallel or perpendicular to the face of the specimen to which pressure is to be applied in the test.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

[3] See p. 829.

(*b*) *Elasticity in Flexure.*—For determining elasticity in flexure, the same size and shape specimens specified in Sections 4 and 5 of the Tentative Method of Flexure Testing of Natural Building Stone (D 327 - 31 T) of the American Society for Testing Materials[1] shall be used.

(*c*) *Elasticity in Compression.*—For determining elasticity in compression, prismatic pieces 3½ by 3½ by 12 in. shall be used, and the sides of the blocks shall be finished to approximate planes.

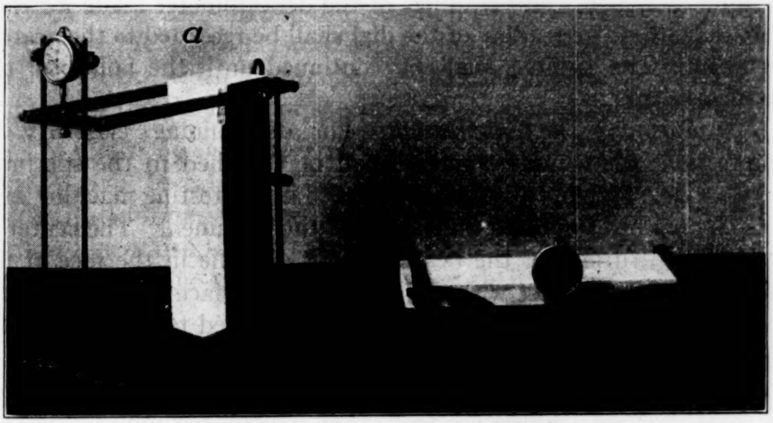

FIG. 1.—Assembled Views of Apparatus for Modulus of Elasticity Test.
(*a*) Compressometer. (*b*) Deflectometer.

(*d*) The specimens shall be cut from the original samples with saws. No hand cutting with chisels or other tools shall be permitted. The load-bearing surfaces shall be finished to as nearly true and parallel planes as possible, grinding wheels or the use of abrasive powders and rubbing plates affording convenient means of obtaining satisfactory surfaces.

Marking Specimens.

4. The load-bearing surfaces and the direction of the bedding planes or rift shall be carefully marked on each specimen after finishing.

Measurements.

5. The dimensions of the specimen shall be measured to the nearest 0.01 in. The width and thickness at the center section shall be used in calculating the elasticity in flexure and also in compression. The length or height of the specimen shall be recorded and the gage length used shall be measured and centered along the length or height.

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[1] See p. 829.

PROCEDURE

Conditioning. 6. (*a*) *Dry Condition.*—Specimens to be tested in the dry condition shall be dried in an oven at a temperature of from 110 to 120° C. for 24 hours immediately preceding the test.

(*b*) *Wet Condition.*—Specimens to be tested in the wet condition shall be completely immersed in water at room temperature for at least two weeks and shall be kept in water until immediately preceding the test.

Procedure. 7. (*a*) *Elasticity in Flexure.*—For determining elasticity in flexure, the slab shall be set up on the knife-edge bearings, the deflectometer attached and an initial load of 20 lb. applied. After setting the dial to approximately zero and noting the readings, the load shall be increased by 10-lb. increments and readings of the deflectometer made for each 50 lb. of load. The reading of the dial shall be recorded to the nearest 0.0001 in. The loading shall be continued until the failure of the specimen occurs.

(*b*) *Elasticity in Compression.*—For determining elasticity in compression, the compressometer shall be attached to the specimen and then the specimen accurately centered in the testing machine with the spherical bearing block on the top of the specimen. The center of the spherical surface of the bearing block shall lie in the face of the bearing block in contact with the top bearing surface of the specimen. The spherical bearing shall be kept well lubricated to insure accurate adjustment which should be made by hand under a small initial load. The speed of the moving head of the testing machine during the application of the load shall be not more than 0.05 in. per minute.

An initial load of 500 lb. shall be applied and the dial set to zero. Load increments of 5000 lb. each shall be applied thereafter up to approximately one half of the estimated breaking load of the specimen, stopping the testing machine at each 5000-lb. loading to read the compressometer, the readings being recorded to the nearest 0.00002 in. After reading at the last 5000-lb. load increment, the load shall be gradually released to 500 lb. and the dial again read. The dial shall then be reset to zero if necessary and a second application of the load made as before. The load shall be fully removed after the reading at 500 lb. following the second load application and the specimen removed from the testing machine. The compressometer shall then be removed and reattached with the specimen turned 90 deg. from its original position. A third application of the load shall then be made as before.

CALCULATIONS

8. (*a*) *Elasticity in Flexure.*—The modulus of elasticity in flexure shall be calculated by use of a load-deflection diagram on which the deflections shall be plotted against the loads. A straight line shall be drawn through the origin parallel to the proportional part of the curve. The modulus of elasticity shall then be calculated from the formula: **Calculations.**

$$E = \frac{wl^3}{4\Delta bd^3}$$

where E = the modulus of elasticity in pounds per square inch;
w = the load ordinate at some convenient point on the line through the origin;
Δ = the deformation ordinate of load point chosen;
l = the length between supporting knife edges in inches;
b = the width of specimen at the center in inches;
d = the thickness of specimen at the center in inches.

(*b*) *Elasticity in Compression.*—The modulus of elasticity in compression shall be calculated by use of a load-deformation diagram on which the deformations shall be plotted against the loads. A straight line shall be drawn through the origin parallel to the proportional part of the curve. The modulus of elasticity shall be calculated from the formula:

$$E = \frac{s}{d} = \frac{P}{A\,d}$$

where E = the modulus of elasticity in pounds per square inch;
s = the unit stress in pounds per square inch;
d = the unit deformation at some convenient point on the line through the origin;
P = the total load on specimen at point corresponding to d on line through the origin;
A = the area of specimen at center section.

REPORT

9. (*a*) Each individual test shall be reported and for the modulus of elasticity of the material the average of all tests shall be used except where an individual result varies from the average of its group more than 25 per cent, in which case such individual result shall be reported as information only. **Reporting Results.**

(*b*) When the load has been applied on a line perpendicular to the bedding or rift planes the result shall be reported as "modulus of elasticity in pounds per square inch perpendicular to the bedding plane or rift."

(*c*) When the load has been applied on a line parallel to the bedding or rift planes the result shall be reported as "modulus of elasticity in pounds per square inch parallel to the bedding plane or rift."

Report. 10. The report shall include the following:

(*a*) The individual and averaged modulus of elasticity in pounds per square inch in flexure or compression for each group of specimens;

(*b*) The types and approximate sizes of specimens used;

(*c*) The condition of the specimen when tested, whether wet or dry;

(*d*) The direction of the application of the load relative to the bedding planes or rift of the specimens;

(*e*) A definite statement as to manner in which specimens were prepared and finished.

TENTATIVE METHOD OF SHEAR TESTING OF NATURAL BUILDING STONE[1]

A.S.T.M. Designation: D 339 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

Scope. 1. This method of test is intended for the determination of the shearing strength of natural building stones used for exterior or interior construction or decorative purposes.

APPARATUS

Testing Machines. 2. Either the modified Johnson shear tool or the Dutton punching shear device may be used in conjunction with any standard testing machine of sufficient capacity. A spherical bearing block of sufficient size to cover the upper end of the plunger of the punching shear device shall be used if that apparatus is employed. Details of the two types of apparatus are shown in Figs. 1 and 2, and assembled views with specimens in place are shown in Fig. 3.

TEST SPECIMENS

Test Specimens. 3. (*a*) Samples shall be representative of the material and shall consist of sections cut from apparently sound material, preferably quarry blocks or slabs. The direction of the bedding planes or rift shall be plainly marked on the samples. The sample shall be of sufficient size to allow the preparation of not less than three specimens having the bedding planes or rift running in the proper direction for the kind of test specified, that is, either parallel or perpendicular to the face of the specimen to which pressure is to be applied in the test.

(*b*) Specimens for use in the Johnson shear tool shall be bars 1 by 2 in. in section and not less than 7 in. in length. For the Dutton punching shear device, slabs 1 in. in thickness, 4 in. in width and not less than 4 in. in length shall be used.

NOTE.—The most convenient form of specimen for the punching shear test is the flat slab obtained when the flexure test is made, the broken pieces of the slab used in the flexure test nearly always being of the proper length while the slab itself was previously cut to 1 in. in thickness and 4 in. in width. The use of these slabs from the flexure test will eliminate the separate preparation of shear test specimens.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

(*c*) The specimens shall be cut from the original samples with saws. No hand cutting with chisels or other tools shall be permitted. The load-bearing surfaces shall be finished to as nearly true and parallel planes as possible, grinding wheels or the use of abrasive powders and rubbing plates affording convenient means of obtaining satisfactory surfaces.

Marking Specimens. 4. The load-bearing surfaces and the direction of the bedding planes or rift shall be carefully marked on each specimen after finishing.

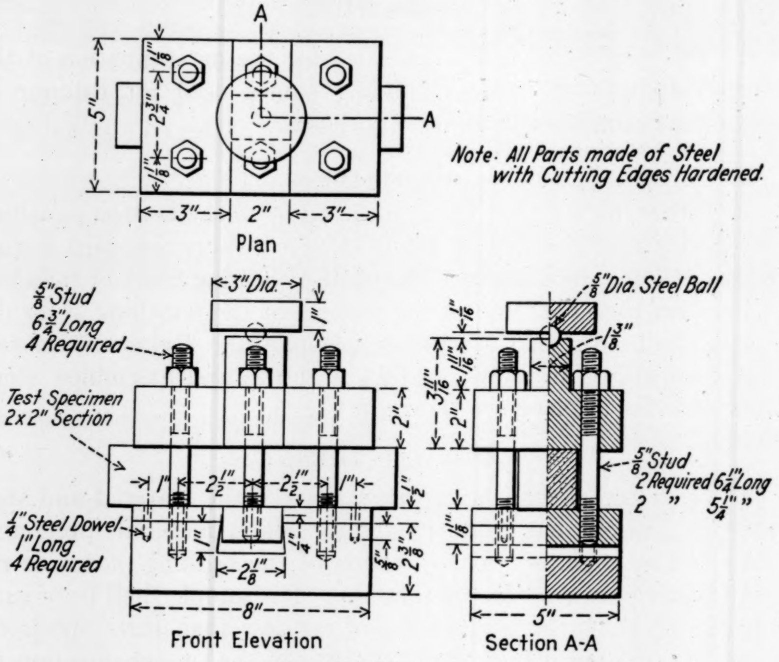
A
A
5"
1/8"
2 3/4"
1/8"
3"
2"
3"
Plan
Note. All Parts made of Steel with Cutting Edges Hardened.
5/8" Stud 6 3/4" Long 4 Required
3" Dia.
1"
Test Specimen 2x2" Section
2"
1"
2 1/2"
2 1/2"
1"
1/2"
1/4" Steel Dowel 1" Long 4 Required
1"
1/4"
2 1/8"
5/8"
2 3/8"
8"
Front Elevation
5/8" Dia. Steel Ball
1/16"
1 3/8"
3 11/16"
11/16"
2"
5/8" Stud 2 Required 6 1/4" Long 2 " 5 1/4" "
1 1/8"
5"
Section A-A

FIG. 1.—Details of Modified Johnson Shear Tool.

Measurements. 5. (*a*) For tests with the Johnson shear apparatus the specimen shall be measured to the nearest 0.01 in. at the center section. The area under shearing stress shall be taken as twice the area of this center section. The length of the specimen shall be included in the report as information only.

(*b*) When using the Dutton punching device, center lines shall be laid off on one surface of the slab and the thickness of the slab measured to the nearest 0.01 in. at not less than three points around the circumference of a 2-in. circle centered on the intersection of the two center lines. The width and length of the specimen shall be included in the report as information only.

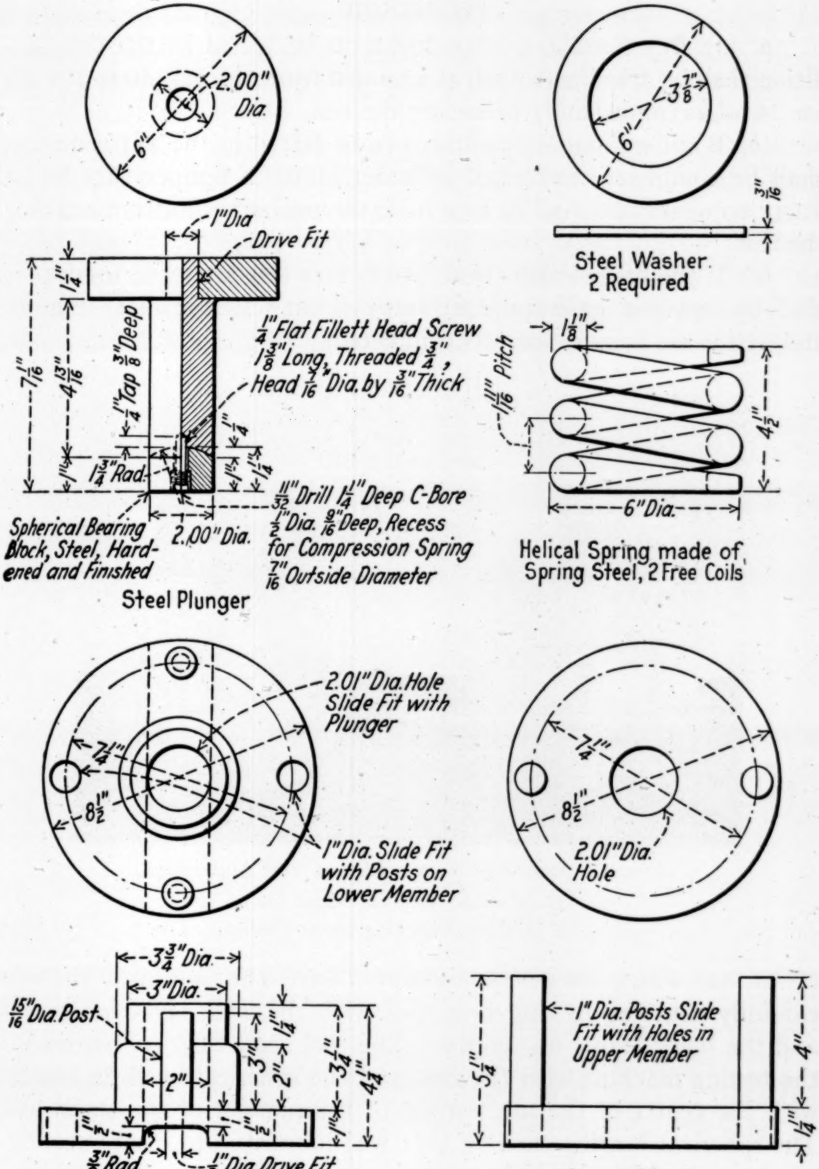
2.00" Dia.
6"
3 7/8"
6"
3/16"
Steel Washer. 2 Required
1" Dia
Drive Fit
1/4"
7 1/16"
4 13/16"
1/4" Tap 3/8" Deep
1/4" Flat Fillett Head Screw 1 3/8" Long, Threaded 3/4", Head 7/16" Dia. by 3/16" Thick
1/4"
1"
1 3/4" Rad.
1"
1 1/4"
11/32" Drill 1 1/4" Deep C-Bore 1/2" Dia. 9/16" Deep, Recess for Compression Spring 7/16" Outside Diameter
Spherical Bearing Block, Steel, Hardened and Finished
2.00" Dia.
Steel Plunger
1 1/8"
11/16" Pitch
4 1/2"
6" Dia.
Helical Spring made of Spring Steel, 2 Free Coils
2.01" Dia. Hole Slide Fit with Plunger
7 1/4"
8 1/2"
1" Dia. Slide Fit with Posts on Lower Member
7 1/4"
8 1/2"
2.01" Dia. Hole
3 3/4" Dia.
3" Dia.
15/16" Dia. Post
1 1/4"
3"
2"
3 1/4"
4 1/4"
2"
1/2"
1/2"
1"
3/8" Rad.
1/2" Dia. Drive Fit
Upper Member
5 1/4"
1" Dia. Posts Slide Fit with Holes in Upper Member
4"
1 1/4"
Lower Member

FIG. 2.—Details of Dutton Punching Shear Device.

PROCEDURE

Conditioning. 6. (*a*) *Dry Condition.*—Specimens to be tested in the dry condition shall be dried in an oven at a temperature of from 110 to 120° C. for 24 hours immediately preceding the test.

(*b*) *Wet Condition.*—Specimens to be tested in the wet condition shall be completely immersed in water at room temperature for at least two weeks and shall be kept in water until immediately preceding the test.

(*c*) If the broken slabs from the flexure test are to be used, they shall be kept in a dessicator until tested if not tested in shear immediately after the flexure test was completed.

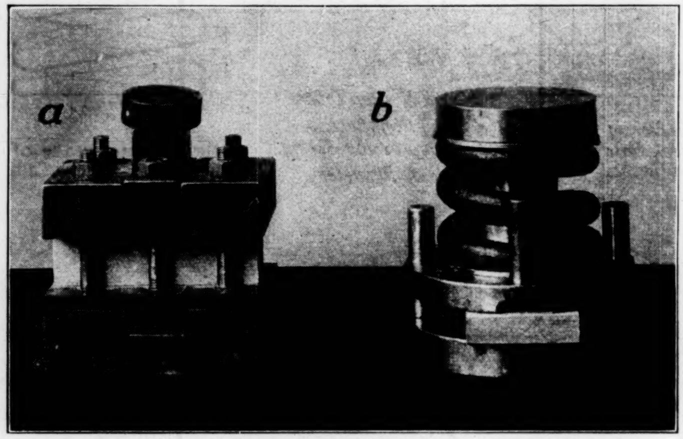

FIG. 3.—Assembled Views of Shear Test Apparatus.
(*a*) Modified Johnson Shear Tool.
(*b*) Dutton Punching Shear Device.

Procedure. 7. (*a*) *Using the Johnson Shear Tool.*—The specimen shall be carefully centered in the shear tool with the 2-in. faces horizontal, and the bolts drawn up tightly. The tool shall then be centered in the testing machine with the center of the spherical block in contact with the center of the top portion of the plunger of the shear tool. The spherical bearing shall be kept well lubricated to insure accurate adjustment which should be made by hand under a small initial load. The speed of the moving head of the testing machine during the application of the load shall be not more than 0.05 in. per minute. During the test the beam of the testing machine shall be kept constantly in a floating position.

(*b*) *Using the Dutton Punching Shear Device.*—The specimen shall be carefully centered between the upper and lower plates of the punching device so that the measured section of the specimen is under the plunger. The upper plate shall be carefully lowered to contact with the specimen. The punching device shall then be centered in the testing machine with the center of the spherical bearing block in contact with the center of the top portion of the plunger of the shear device. The spherical bearing shall be kept well lubricated to insure accurate adjustment which should be made by hand under a small initial load. The speed of the moving head of the testing machine during the application of the load shall be not more than 0.05 in. per minute. During the test the beam of the testing machine shall be kept constantly in a floating position.

CALCULATIONS

8. The shearing strength in pounds per square inch shall be calculated as follows: **Calculations.**

(*a*) *Using Johnson Shear Tool.*—The shearing strength shall be calculated from the formula:

$$S = \frac{W}{A}$$

where S = the shearing strength in pounds per square inch;
W = the total maximum load in pounds indicated by the testing machine;
A = twice the area in square inches of the center section of the specimen.

(*b*) *Using the Dutton Punching Device.*—The shearing strength shall be calculated from the formula:

$$S = \frac{W_T - W_I}{A}$$

where S = the shearing strength in pounds per square inch;
W_T = the total maximum load in pounds indicated by the testing machine;
W_I = the initial load in pounds required to bring the plunger in contact with the surface of the specimen;
A = the area of the specimen under load obtained from the circumference of the plunger and the thickness of the specimen.

REPORT

9. (*a*) Each individual test shall be reported and for the shearing strength of the material the average of all tests shall be used except where an individual result varies from the average of its group more than 25 per cent, in which case that individual result shall be reported as information only. **Reporting Results.**

(*b*) When the load has been applied on a line perpendicular to the bedding or rift planes the result shall be reported as "shearing strength in pounds per square inch perpendicular to the bedding plane or rift."

(*c*) When the load has been applied on a line parallel to the bedding or rift planes the result shall be reported as "shearing strength in pounds per square inch parallel to the bedding plane or rift."

Report. 10. The report shall include the following:

(*a*) The individual and averaged shearing strengths in pounds per square inch for each group of specimens;

(*b*) The type and approximate sizes of specimen used;

(*c*) The condition of the specimen when tested, whether wet or dry;

(*d*) The direction of the application of the load relative to the bedding planes or rift of the specimens;

(*e*) A definite statement as to manner in which specimens were prepared and finished;

(*f*) The type of shear appliance used.

TENTATIVE DEFINITIONS OF TERMS RELATING TO NATURAL BUILDING STONE[1]

A.S.T.M. Designation: D 340 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.[2]

In preparing these definitions care has been taken to avoid including technical details of geology and mineralogy not essential to commercial usage.

Stone.—Any natural rock deposit or formation of igneous, sedimentary and/or metamorphic origin, either in its original or altered form.

Building Stone.—The quarried product of any natural rock deposit, or formation previously defined as "stone" (other than crushed or broken stone used as an aggregate) which, by reason of its physical and chemical properties, æsthetic characteristics and resistance to deterioration upon exposure to weathering, is suitable for structural and ornamental purposes in the exterior of buildings and other structures of either architectural, memorial or engineering character (see Explanatory Notes, page 847).

NOTE.—The above definition is not intended to cover or provide for certain marbles or other stones used especially for interior decoration.

Granite.—Any natural igneous rock formation of visibly crystalline texture.

NOTE.—For commercial purposes the gneisses and schists suitable for building usage, are included under the general classification as granite under this definition.

Building Granite.—Granite possessing the properties and characteristics required for building stone.

Basalt.—Any volcanic rock of micro-crystalline or amorphous texture, dark color and high true specific gravity, including porous or vesicular basalt which by reason of its structure has a low apparent specific gravity.

Limestone.—Any natural rock of sedimentary origin composed principally of calcium carbonate or of calcium and magnesium carbonates in either its original chemical or fragmental, or recrystallized form.

Building Limestone.—Limestone possessing the properties and characteristics required for building stone.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. H. S. Brightly, Secretary of Committee D-18 on Natural Building Stones, Box 54, Bloomington, Ind.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

Oolitic Limestone.—A variety of limestone quarried principally for building purposes, which is primarily a calcareous-sand rock formation, composed largely of shells and shell fragments. (See definitions of *Limestone* and *Building Limestone.*)

Dolomite.—A magnesium limestone, composed essentially of the mineral dolomite, a double carbonate of calcium and magnesium. (See definitions of *Limestone* and *Building Limestone.*)

Marble.—Any crystalline or micro-crystalline natural rock deposit of sedimentary origin composed principally of calcium carbonate or calcium and magnesium carbonates, or serpentine, the crystalline character of which has reached the stage which permits it to take a polish. This classification includes also those serpentines that are of igneous origin as well as those of sedimentary origin.

Building Marble.—Marble possessing the properties and characteristics required for building stone.

Decorative Marble.—Marble, including also those natural stones not strictly marble, such as serpentine and the semi-crystalline fossilferious or so-called "fancy" limestones, that will take a high polish, which by reason of their coloring and marking, or other physical properties, or both, are suited more particularly for interior decorative purposes.

Dolomite Marble (A Magnesium Marble).—See definitions of *Dolomite, Marble, Building Marble, Decorative Marble.*

Sandstone.—Any natural rock of sedimentary origin composed primarily of silica or silicate grains, compacted or cemented together in any way by nature.

Quartzite.—Any quartz sandstone thoroughly cemented by silica or indurated by recrystallization.

NOTE.—This definition includes also "semi-quartzite."

Building Sandstone.—Sand or quartzite possessing the properties and characteristics required for building stone.

Building Slate or Argillite.—Any thoroughly compacted and indurated natural shale deposit capable of being quarried in layers or blocks for building use, which, by reason of its physical and chemical properties, æsthetic characteristics and resistance to deterioration upon exposure to weathering, is suitable for structural or ornamental purposes in the exterior of buildings and other structures of either architectural, memorial or engineering character.

Igneous Rock.—Any rock of Plutonic or volcanic origin.

Volcanic Rock.—Any igneous rock of micro-crystalline or amorphous texture.

NOTE.—This includes rhyolite, andesite, basalt.

Sedimentary Rock.—Any rock formed by the deposition of particles from water whether from matter held in suspension or from the crystallization or coagulation of matter held in solution.

Metamorphic Rock.—Any rock formation which, in the natural ledge, has undergone marked change in micro-structure and/or character due to heat, pressure or moisture or a combination of these agencies of nature and thus exists in a form different from its original form.

Trap Rock.—An indefinite term, often applied to basalt and other volcanic rocks of micro-crystalline texture, but sometimes also applied to certain kinds of semi-metamorphic sedimentary rock and therefore a term which cannot be suitably defined for technical purposes.

EXPLANATORY NOTES

The terms "structural," "ornamental," "decorative," "architectural," "memorial" and "engineering" as employed in the foregoing definitions are explanatory rather than definitive and are used to designate what may be somewhat broadly defined as follows:

Structural.—A material and/or system of construction capable of safely supporting loads in addition to its own weight and resist stresses imposed by external agencies, within the limits of the safe working properties specified for that kind or grade of material and/or system of construction, as the result of properly conducted tests.

Ornamental.—A material and/or method of use, capable of employment for the finished exteriors of building structures that is durable and capable of resisting the action of the elements in a satisfactory manner when so exposed, with out deterioration that in any way seriously impairs its suitability for the finished exterior of so-called permanent building structures.

Decorative.—A material and/or method of use intended primarily for decorative purposes, in which structural value for the support of loads or resistance to stress and ornamental value from the standpoint of resistance to weather action in exposed exterior locations are not essential characteristics.

Architectural.—Building structures of all kinds which enclose interiors that are utilized for some specific purposes in the activities of human life, administrative, educational, religious, institutional, commercial and industrial, recreational and habitational.

Memorial.—Ornamental structures of all kinds in which the enclosed interiors, where present, are generally of minor importance and not customarily used to house the activities of human life, including monuments, mausoleums and memorial structures, fountains, arches, gateways, bandstands and other structural landscape embellishments, other than structures of so-called engineering types.

NOTE.—The term memorial as thus defined will of course include many structures of architectural character, which, for sake of convenience in the work of this committee, are embraced under the memorial classification.

Engineering.—Structures of all kinds devised to perform some important function other than the housing of human activity, such as bridges and culverts, viaducts, aqueducts, dams, street and parkway systems.

TENTATIVE METHODS OF TESTING VARNISHES USED FOR ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 115 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1923, 1924, 1925, 1926, 1928, 1929, 1930, 1931.

Scope. 1. These tests are intended for varnishes which are applied by brushing, dipping or spraying, and are primarily for the purpose of providing electrical insulation.

SPECIFIC GRAVITY

Specific Gravity. 2. The specific gravity shall be measured with a pycnometer, Westphal balance or with a hydrometer so graduated that the specific gravity can be determined to 0.001. The temperature of the varnish shall be not less than 18° C. (64.4° F.) nor more than 22° C. (71.6° F.) and corrected to 20° C. (68° F.) by applying a correction of 0.0007 per 1° C. (0.0004 per 1° F.).

VISCOSITY

Viscosity. 3. The viscosity shall be determined at 20° C. (68° F.) and the results shall be stated in terms of absolute viscosity — poise[2] or centipoise (centipoise = 0.01 poise).

NOTE 1.—When measurements are made by an indirect method, the instrument used must be standardized. Oils of standard viscosity for use in standardizing such instruments can be obtained from the U. S. Bureau of Standards.

NOTE 2.—A description of the MacMichael viscosimeter as remodeled and improved for varnish testing together with directions for its calibration in absolute units appears in Appendix I.

FLASH POINT

Procedure for Flash Point. 4. The flash point shall be determined in accordance with the Standard Method of Test for Flash Point of Volatile Flammable

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] The absolute viscosity of a material or its viscosity in absolute units (c.g.s., poises) has been defined as the force in dynes required to move, at a velocity of 1 cm. per second, one surface having an area of 1 sq. cm. past another parallel like surface 1 cm. away, overcoming the resistance to shear of the material filling the space between.

Liquids (A.S.T.M. Designation: D 56) of the American Society for Testing Materials.[1]

TIME OF DRYING

Test Specimen.

5. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about 4 cm. (1.57 in.) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

(*b*) The specimen shall be dipped once in the varnish at a room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The consistency of the varnish shall be first so adjusted by trial that, when dry as determined in accordance with Section 7, the average thickness of the film of varnish on each side of the metal shall be between 0.022 and 0.026 mm. (0.0009 and 0.001 in.) Care shall be taken before dipping the specimens that the varnish has stood in the dipping tank for a sufficient length of time to be free from air bubbles.

Procedure

6. (*a*) Specimens of air-drying varnish shall be dried in dust-free air at a room temperature of approximately 20° C. (68° F.).

(*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger at a point approximately 2 in. from the bottom will not become obliterated by further flow of the material. They are then to be dried in dust-free air in an oven at 105 to 110° C. (221 to 230° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined. In the case of slow-drying varnishes, this 10-minute period may be lengthened at the discretion of the operator.

NOTE.—The size of oven and the amount of ventilation have a considerable effect on the drying time of varnishes. For this reason the analytical type of electrically-heated oven should be used.

Time of Drying.

7. The varnish shall be considered dry when a piece of kraft paper 38 mm. (1.49 in.) in width and 152 mm. (6 in.) in length and approximately 0.063 mm. (0.0025 in.) in thickness does not adhere to the varnish when it is pressed on the surface of the varnish for one minute by a cylindrical 1-lb. weight, 1 in. in diameter. The kraft paper shall be applied in the vicinity of the center of the specimen and at right angles to it. The test shall be made at a temperature of approximately 20° C. (68° F.).

NOTE.—Certain types of varnishes dry with what is commonly known as a "tack"; but these types are rare. However, when testing them for drying time, it will be found that the kraft paper adheres to the varnish film and offers a certain amount of resistance to removal. On continued drying, the resistance to removal reaches constancy and is not changed by further drying. Therefore, the drying time is reported as the number of hours required to first reach constancy and the varnish should be reported as drying with a "tack."

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 362.

DIELECTRIC STRENGTH TEST[1]

Scope. 8. (*a*) This test is intended to determine the suitability of an insulating varnish for use in certain electrical applications by taking the dielectric strength test under different conditions of temperature and after immersion in water. The test provides for the determination of dielectric strength under the following conditions:

(*1*) At room temperature (approximately 20° C.) in air.

(*2*) At 75° C. in air.

(*3*) At room temperature after immersion in water of approximately 20° C. (68° F.) for a period of 24 hours.

NOTE.—Dielectric strength determinations may also be made at room temperature and at 75° C. in oil. With this exception the procedure for test is the same as outlined here. If tests are made in oil this fact must be definitely reported with the results.

(*b*) Much more information about a varnish can be obtained by making the test under all three conditions than by making it under only one condition. The relation which the dielectric strength tests for a given varnish show to one another, is of quite as much significance as the values for the different tests considered separately.

Test Specimens. 9. (*a*) Specimens for the dielectric strength test shall be prepared by dipping pieces of kraft paper about 20 cm. (7.88 in.) square and about 0.076 mm. (0.003 in.) in thickness into the varnish which shall be at the consistency specified in Section 5 (*b*).

NOTE.—The paper used shall be that which is commercially known as No. 1 sulfate kraft. The surface of the paper shall be smooth, free from pimples or lumps and reasonably free from hairy fibers. The paper shall also be free from conducting particles, slime spots, creases, cuts, specks or other "paper defects."

(*b*) Each specimen shall be dipped twice, as specified in Section 5 (*b*), once in each direction, in order to give a more uniform thickness of coating. The specimen shall be dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish shall be dried in dust-free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period six times that determined in accordance with Section 7.

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[1] This test is relative only, but it gives more uniform results than those obtained with a copper base. See Appendix II for a procedure for determining the dielectric strength on a copper base, p. 866.

(*d*) Specimens of baking varnish shall be drained and then baked in dust-free air at a temperature of 105 to 110° C. (221 to 230° F.) after each dip for a period three times that determined in accordance with Section 7.

(*e*) The final thickness of the specimen shall be 0.152 mm. (0.006 in.) to within ±15 per cent.

Procedure.

10. (*a*) The dielectric strength of the specimen shall be determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being too close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined by the American Institute of Electrical Engineers,[1] and the voltage shall be measured by methods approved by the same organization.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 100 volts. The apparatus shall comply with the standards of the American Institute of Electrical Engineers.[1]

Test Conditions.

11. The dielectric strength shall be determined under the following conditions:

(*a*) At room temperature (approximately 20° C.) in air.

(*b*) At 75° C. in air.

NOTE.—The tests at 75° C. shall be made in air in an analytical type of electrically-heated oven. The electrodes shall be at oven temperature before the test is started. Tests should be started 15 minutes after the specimen has been introduced into the oven and placed between the electrodes and completed before 15 minutes additional have elapsed.

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[1] Standards of the American Institute of Electrical Engineers.

(*c*) At room temperature on specimens which shall have been immersed in water at a room temperature of approximately 20° C. (68° F.) for a period of 24 hours.

NOTE 1.—In testing specimens after immersion in water, only one specimen should be removed from the water at a time. The specimen after removal from the water should be carefully dried by placing between sheets of dry blotting paper and pressing down gently with the hand over the entire surface. If necessary, the blotting procedure should be repeated until the specimen is free from surface moisture. The specimen should then be tested immediately. If specimens are allowed to remain out of water for even a short time before testing, they dry out to a greater or less extent and the test is apt to be misleading.

NOTE 2.—Dielectric strength determinations may also be made at room temperature and at 75° C. in oil. With this exception the procedure for test is the same as outlined above. If tests are made in oil this fact must be definitely reported with the results.

Report. 12. In reporting the results for each of the three tests made as described in Section 11, the total voltage at puncture, the thickness of the specimen and the volts per mil of thickness shall be reported for each of the ten punctures together with the average, maximum and minimum values. In addition, the average dielectric strength in volts per mil of the test made at 75° C. and of the test made after water immersion shall be expressed as a percentage of that made at room temperature.

HEAT ENDURANCE TEST

Test Specimens. 13. (*a*) Specimens shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or sheet brass about 20 cm. (7.88 in.) in length, 3 cm. (1.18 in.) in width and 0.127 mm. (0.005 in.) in thickness, into the varnish. The consistency of the varnish shall previously be adjusted by trial so that, when dry as determined in accordance with Section 7, the average thickness of the film of varnish on each side of the metal shall be between 0.022 and 0.026 mm. (0.0009 and 0.001 in.).

(*b*) Each specimen shall be dipped in the varnish at room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The varnish shall be allowed to dry in the air (if an air-drying varnish) or baked in an oven at 105 to 110° C. (221 to 230° F.) (if a baking varnish) until dry as determined in accordance with Section 7. As soon as the first coat of varnish is dry, and the specimen is at room temperature, it shall be dipped again in the varnish in the reverse direction so as to give a uniform thickness of coating. The second coat of varnish shall be allowed to dry in the same manner as the first coat. When the second coat of varnish is dry, the specimen shall be measured. The thickness of varnish on each side of the metal shall be between 0.044 and 0.052 mm. (0.00173 and 0.00205 in.).

Procedure. 14. (*a*) The specimens shall be placed in a uniformly-heated oven, in which the temperature is maintained at 105 to 110° C. (221 to 230° F.). A specimen shall be removed at the end of the first 24 hours and every 24 hours thereafter.

NOTE.—Because of temperature variations between different levels in the oven, the specimen should be placed in the oven with the 8-in. dimension horizontal and the 1-in. dimension vertical. All specimens should be at the same level in the oven.

(*b*) Each specimen, after heating, shall be tested at room temperature of approximately 20° C. (68° F.) by bending it through 180 deg. around a rod 0.32 cm. (0.125 in.) in diameter.

Report. 15. The number of hours of baking of the specimen which first showed cracking of the varnish film shall be reported, together with the make and type number of the oven used.

NOTE 1.—This size of oven and the amount of ventilation have a considerable effect on the heat endurance of varnish films. For this reason the analytical type of electrically-heated oven should be used.

NOTE 2.—The temperature of the oven should be held as closely as possible to the mean (107.5° C., 225.5° F.). A difference of 5° C., (9° F.) in this temperature range, when continuously maintained, has a very considerable effect (approximately 25 per cent) on the life test of a varnish.

NOTE 3.—As the "grain" of the copper influences the result of the test, the heat endurance test specimens should be prepared by cutting the copper strips parallel with the direction of rolling.

OIL PROOF TEST

Oil Test Specimen. 16. (*a*) To test for the effect of oil, the specimens shall be prepared as prescribed in Section 13 (*a*).

(*b*) The specimens shall be dipped and dried as prescribed in Section 9 (*b*), (*c*) and (*d*).

Procedure. 17. The effect of oil on the varnish shall be determined by immersing the specimens in transformer oil at a temperature of 105 to 110° C. (221 to 230° F.) for 48 hours and noting the effect on the varnish as indicated, for example, by wiping with a piece of dry white cloth.

NOTE.—Incipient disintegration of the surface of the varnish may sometimes be detected by examining the oil for turbidity. If a specimen of the used oil filtered through filter paper can be distinguished from an unfiltered sample of the used oil, when the two samples in identical containers are held in front of a diffused light, the oil is turbid.

DRAINING TEST

(ALSO KNOWN AS "WORKING VISCOSITY" TEST)

Test Specimen. 18. A strip of sheet copper or brass about 4 cm. (1.57 in.) wide, 35 cm. (13.78 in.) long, and 0.127 mm. (0.005 in.) thick, shall be immersed in the varnish at a room temperature of approximately 20° C. (58° F.) up to a line previously drawn across the strip 1 in. from the top. The sheet shall be withdrawn at a slow and uniform rate (about 38 cm. (15 in.) per minute), care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

Measurements. 19. The thickness of the specimen in mils shall be measured at points 5.1 cm. (2 in.), 17.8 cm. (7 in.) and 30.5 cm. (12 in.), respectively, from the line to which the specimen was immersed.

Report. 20. The thickness of each film in mils at the three points specified in Section 19 shall be recorded. The difference between the thickness at the upper point (5.1 cm.) and that at the lower point (30.5 cm.) shall be taken as a measure of the variation in the film thickness caused by draining.

TEST FOR NON-VOLATILE MATTER BY WEIGHT

Procedure. 21. A portion of the sample shall be placed in a stoppered bottle or weighing pipette and weighed. About 1.5 g. of the sample shall be transferred to a weighed flat-bottom metal dish about 8 cm. (3.15 in.) in diameter, such as the cover of a friction-top tin can. The container shall again be weighed and the exact weight of the portion of the sample transferred to the weighed dish calculated by difference. The dish with its contents shall be heated for three hours in an oven maintained at 105 to 110° C. (221 to 230° F.). It shall then be weighed after cooling.

Non-Volatile Matter. 22. The ratio of the weight of the residue to the weight of the original sample expressed as a percentage shall be taken as the percentage of non-volatile matter by weight in the varnish.

TEST FOR VOLATILE MATTER BY VOLUME

Scope. 23. This test is intended to determine the volume percentage of volatile matter (solvent) in a varnish, and to afford a means of arriving at the volume composition of the varnish with respect to volatile (solvent) and non-volatile (base) constituents.

Procedure. 24. (*a*) About 100 ml. of the varnish shall be distilled in accordanc with the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (A.S.T.M. Designation: D 86) of the American Society for Testing Materials.[1] The distillation shall be "qualitative" instead of "quantitative" as given in Section 9 of the Standard Method D 86; that is, it is not necessary to record the volume of distillate recovered, or the temperature of the initial boiling point or end point.

(*b*) The distillation shall be continued until a suitable end point indicates that all the volatile matter (solvent) has been distilled off.

NOTE.—In the distillation of varnishes the end point differs with the various types and compositions. In all cases, however, the rate of distillation slows down as the end point is approached; and, when the end point is reached, acrolein (formed in the decomposition of the varnish base) is evolved and may be detected by its characteristic odor.

In addition to the evolution of acrolein, the following phenomena are suitable indicators of end point:

(1) When the end point of the solvent is considerably lower than the initial boiling point of the base, the end point of the distillation is indicated by the temperature reaching a maximum and then starting to fall consistently.

(2) When the end point of the solvent and the initial boiling point of the base are too close, or overlap, the above temperature drop does not occur. The end point of the distillation is then indicated by a sudden foaming up of the residual base in the distillation flask; or, if the distillation has been accompanied by foaming, the end point is indicated by a breaking of surface tension with a consequent cessation of foaming.

Specific Gravity.

25. The specific gravity of the volatile matter (solvent) recovered by distillation shall be determined in accordance with the procedure described in Section 2

Volatile Matter by Weight.

26. The difference between 100 per cent and the percentage of non-volatile matter determined in Sections 21 and 22 shall be calculated and recorded as the percentage of volatile matter by weight.

Volatile Matter by Volume.

27. The percentage of volatile matter by volume shall be calculated from the formula:

$$x = \frac{AC}{B}$$

where

x = the percentage of volatile matter by volume;
A = the specific gravity of the original varnish, as determined in Section 2;
B = the specific gravity of the volatile matter (solvent) recovered by distillation, as determined in Section 25; and
C = the percentage of volatile matter by weight, as determined in Section 26.

Accuracy.

28. With proper care and attention to detail in making this test, differences occurring between different laboratories should not exceed

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 491.

2 per cent for varnishes containing solvents which have end points not over 235° C. (455° F.), and should not exceed 4 per cent when the end point of the solvent is as high as 307.2° C. (585° F.).

DIELECTRIC STRENGTH OF VARNISH IN THE LIQUID STATE

Scope. 29. The purpose of the dielectric strength test of varnish in the liquid state is to insure that the varnish is free from moisture and foreign matter such as might come from unclean shipping containers.

Apparatus. 30. The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Materials Used for Electrical Insulation (A.S.T.M Designation: D 48) of the American Society for Testing Materials.[1] The test cup for holding the sample of varnish shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by mineral oil and gasoline and non-absorbent so far as moisture, mineral oil and gasoline are concerned. The electrodes in the test cup between which the sample is tested shall be circular disks of polished brass or copper, 1 in. in diameter and having square edges. The electrodes shall be mounted in the test cup having their axes horizontal and coincident, with a gap of 0.1 in. between their adjacent faces, and with top of electrodes about 33 mm. ($1\frac{1}{4}$ in.) below the top of the cup.

Procedure. 31. (*a*) The electrodes and the test cup shall be wiped clean with dry calendered tissue paper or with a clean dry chamois skin, and thoroughly rinsed with a suitable solvent such as dry benzol or redistilled carbon tetrachloride. The electrodes and test cup shall then be rinsed with some of the varnish to be tested.

(*b*) The spacing of electrodes shall be checked with a standard round gage having a diameter of 0.100 in. and the electrodes then locked in position. Care shall be taken not to touch the electrodes with the gage or in any other manner after cleaning the electrodes and cup, so as to avoid any possible contamination.

(*c*) The temperature of the varnish when tested shall be the same as that of the room, which should be between 20 and 30° C. (68 and 86° F.).

(*d*) The sample of the varnish shall be shaken so that it will be thoroughly mixed before filling the test cup, the shaking shall be done gently to avoid the formation of bubbles.

(*e*) The cup shall be filled with varnish to a height of not less than 20 mm. (0.787 in.) above the top of the electrodes.

(*f*) The varnish shall be allowed to remain in the test cup until all air bubbles have disappeared.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 985.

(*g*) Voltage shall be applied and increased uniformly at the rate of approximately 3 kv. (r.m.s. value) per second until electrical breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

(*h*) After the breakdown and before removing the varnish from the test cup, the electrode surfaces shall be rubbed thoroughly with dry calendered tissue paper wrapped around a knife blade to provide stiffness. The test cup shall then be emptied and immediately refilled with the next filling of varnish to be tested.

(*i*) Five fillings shall be tested in conformity with the above procedure and the last filling of the cup shall drain the sample container.

Variations in Results.

32. Differences as great as 15 per cent may occur between different laboratories in the results of this test. This is considered satisfactory in view of the purpose of the test.

Report.

33. The report shall include the following:

(*a*) The kilovolts (r.m.s. value) at each electrical breakdown;

(*b*) The average value of the 5 breakdowns in kilovolts; and

(*c*) The mean deviation from the average value expressed as a percentage of the average breakdown value.

APPENDIX I

DESCRIPTION AND USE OF REMODELED MACMICHAEL VISCOSIMETER FOR DETERMINING VISCOSITY OF INSULATING VARNISHES

APPARATUS

The viscosity of varnishes may be determined by means of the remodeled MacMichael Viscosimeter shown in Figs. 1, 2 and 3. This instrument gives the viscosity values in terms of MacMichael degrees which are converted into absolute units of viscosity (centipoise) by means of the calibration curves of the various suspending wires.

In Fig. 1 the apparatus, consisting of the following parts, is shown unassembled:

A is the indicator by means of which the zero is adjusted and readings on scale *D* are taken.

B is the insulated wire suspension, the torsion of which measures the viscosity. The wire is fastened only at the bottom of its insulating sleeve *E'*. This is suspended by hanging it on points *P'*. (Ten wires of different size to cover various ranges of viscosities are supplied.)

C is the clamp screw which clamps the hollow spindle *E* to the sleeve *E'* which holds the torsion wire *B*.

D attached to hollow spindle *E* is the dial on which are calibrated the degrees MacMichael (300 deg. to the circumference). By means of this dial and indicator *A* the degrees deflection are determined as indicated in the method described below.

E is the hollow vertical spindle inside of which is the torsion wire sleeve *E'* which contains torsion wire *B*.

F is an oil-filled dash pot which acts as a brake to deaden oscillations and bring the suspension to rest quickly when making a determination. The dash pot swings between arm guides *F'* when the machine is assembled.

G is the brass disk which is attached to the bottom of vertical spindle *E*. Torsion wire *B* and *E'* is inserted into *E* and clamped with screw *C* and the disk *G* is then suspended in the liquid whose viscosity is being measured. Rotation of the sample cup *H* rotates the liquid and the rotating liquid exerts a certain force on the disk *G* partially rotating it and thus a torsion is produced in the wire suspension *B*, the deflection of which (or degree of torsion) is read from the scale on deflecting disk *D*.

H is the container which holds the sample. A locking device fastens it securely to *I* or *J*.

I is the water bath used for securing a uniform temperature in the liquid whose viscosity is being determined, when these viscosity measurements are desired at temperatures approximating that of the room (used on varnishes and oils).

J is the heating unit which is used in place of *I* when viscosity measurements are made at high temperatures (used on compounds).

K is the contact which carries the electric current to the heating unit cup *J*. It can be swung back when using cups *H* and *I* and when therefore electric heating is not desired.

L is the counter which indicates the revolutions per minute of the turntable *M*. A trip arrangement allows this counter to be lowered or raised, thus throwing the counter in or out of operation at will.

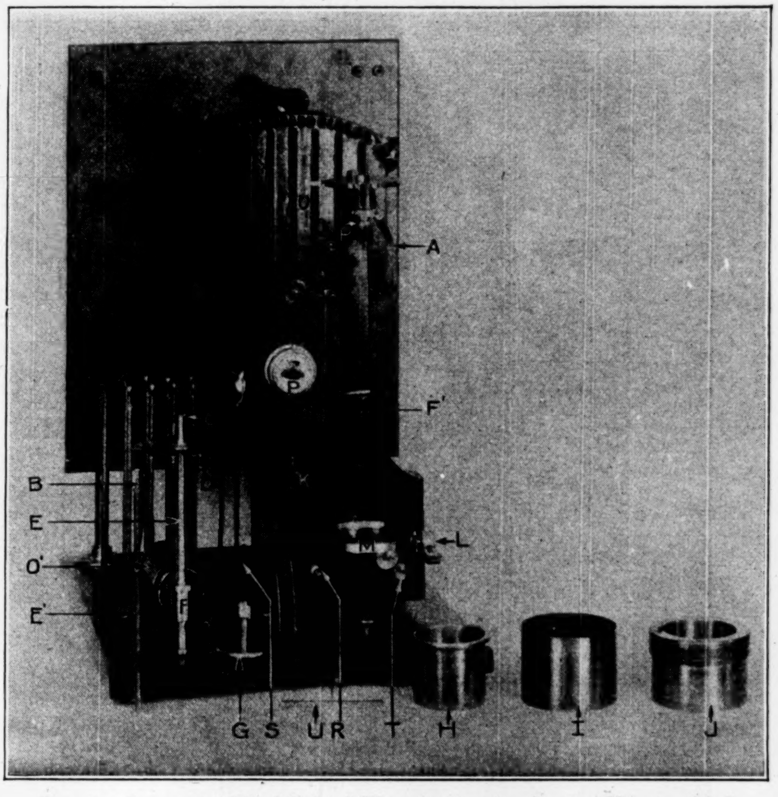

FIG. 1.—Improved MacMichael Viscosimeter Apparatus, Unassembled.

M is the rotating turntable in which *I* or *J* are set. A locking device (not shown) locks *I* or *J* securely to the turntable *M* so that when the turntable rotates the water bath or heating unit with the sample container also rotate.

N is the inclosing case under which is the motor and governor shown in Fig. 3. These operate turntable *M*.

O is a rheostat which controls the current going to the heating unit *J*.

O' is a rheostat controlling current for motor (shown only on remodeled instruments).

P is the knife switch (snap switch on new type machine) controlling the current for the heating unit *J*.

R is the push button which controls the electric current operating the motor shown in Fig. 3.

S is a leveling screw to level the instrument. Another such screw (not shown) is directly opposite to this one.

T is the governor screw that adjusts the speed of the motor by adjusting the governor shown in Fig. 3. In the remodeled apparatus the speed of rotation of turntable *M* can be decreased by moving the large gear in gear box away from the motor until pin of motor shaft is disengaged from slot of gear sleeve. The instrument is sent out with gear in low-speed position; to obtain high speeds shift gear toward motor until pin is engaged.

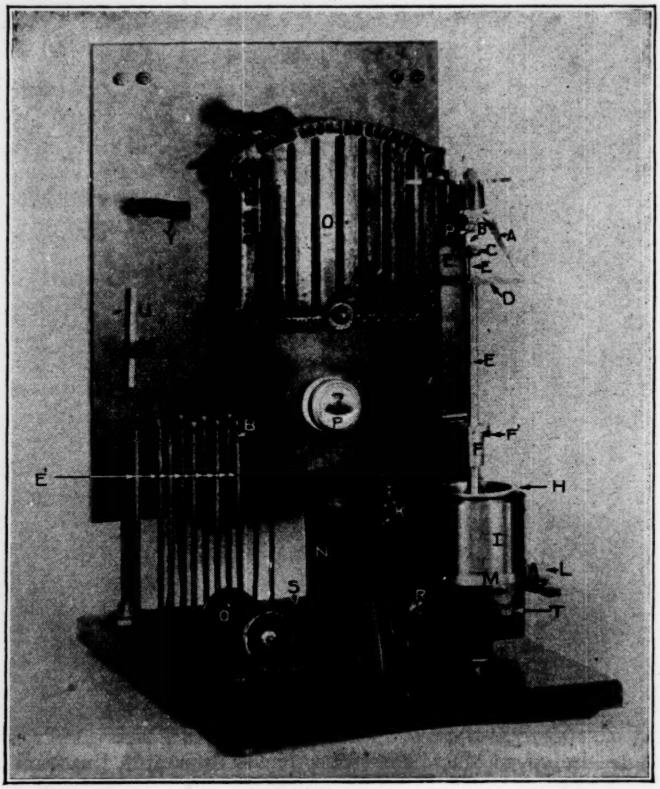

FIG. 2.—Improved MacMichael Viscosimeter Apparatus Assembled for Testing Varnish or Oil.

U is the measuring device used to measure the depth of the liquid in container *H*.

p are the projecting points on which the assembled spindle, namely, insulated torsion wire suspension *B* and *E'*, spindle and deflection dial *D*, and immersed disk *G* are suspended.

The apparatus is shown assembled in Fig. 2 for viscosity determinations on oil or varnish. Explanatory letters refer to the same parts as in Fig. 1.

In Fig. 3 are shown the internal structure and cup and heating unit assembled for testing compounds. The explanatory letters refer to the following:

V is the motor which operates the turntable *M*.

W is the governor controlling the speed of the turntable *M*.

X are the leads to connect instrument to 110-volt alternating current or direct current lighting circuit.

Y is the clamp holder for holding the spindle *E* with its dial *D*, when the machine is not in use (remodeled machines).

The heating unit *J* and the sample container, *H*, are here shown assembled as used in the viscosity determinations on compounds.

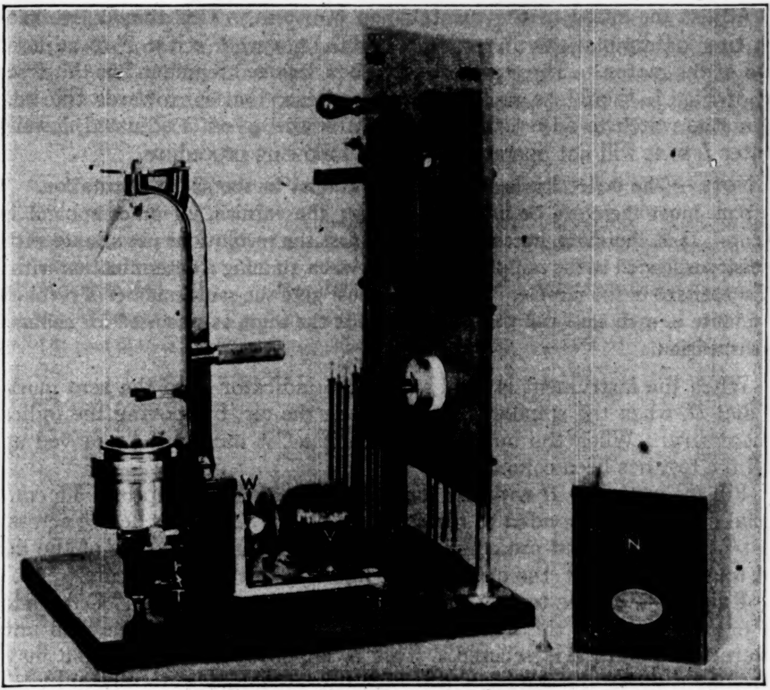

FIG. 3.—Improved MacMichael Viscosimeter Apparatus Showing Internal Structure and Cup and Heating Unit for Testing Compounds.

DIRECTIONS FOR MAKING VISCOSITY MEASUREMENTS ON VARNISH

Cups and disks must be perfectly clean. Otherwise reliable results cannot be obtained.

Dash pot *F* on the stem of the spindle should be two-thirds full of a medium grade of good machine oil (Etna Engine or Appollo) in order to dampen vibrations.

Use water bath *I* to secure and maintain the temperature of the sample in *H* when testing varnishes or oil.

Insert container *H* into water bath *I*. See that they are properly locked together, then lock bath *I* on turntable *M*.

Choose the proper torsion wire suspension for the liquid to be tested. Experience is the best guide to determine what suspension to use. Screw the disk *G* to the spindle *E*, and insert into *E* the proper insulated torsion wire suspension *E'*. Suspend these assembled parts from points *p* so the disk is suspended in the container *H*. Be sure to always suspend the wire on the points *p* with the flat side of the triangular button against the flat side of the supporting arm. The rounded surface of the triangle must face out towards the operator. Tightly fit the cover of the dash pot *F* on the arm guides F'.

See that the instrument is perfectly level. Use leveling screws *S* to adjust the instrument. The instrument is level when the suspended sleeve *E* swings exactly in the center of the hole of the cover on the dash pot.

Adjust the speed of the turntable to 60 r.p.m. This should be checked each time determinations are made. Use the governor screw *T* to adjust the speed of the motor. The gear in the gear box, referred to under *T* in the description of Fig. 1, should be in high speed position, that is, towards the motor. Use a stop watch to adjust the speed. After the speed is adjusted, lower the counter *L* so it will not operate during the following procedure.

NOTE.—The deflection is directly proportional to the speed of rotation. The 60 r.p.m. must therefore be maintained when the varnish, oil or compound is in the cup. It is, therefore, necessary to check first the revolutions per minute without the disk suspended in the sample, and again, when running a determination with the disk suspended in the sample. The motor must give the same number of revolutions per minute in each case and this value must be the same as was used for calibrating the suspension.

When the instrument is level adjust the indicator *A* to the zero mark on the dial *D*, when the spindle is suspended in the air, by moving the indicator as necessary. When the indicator has been set it must not be moved again until the test has been completed.

Fill the container *H* with the sample to be tested to a depth of 3.5 cm. A special device *U* is provided to measure this depth. Lay this device across the cup so the pointed end projects into the cup. When the surface of the liquid just touches the point, the depth of the liquid in the cup is 3.5 cm.

Raise or lower the temperature of the oil or varnishes to 21° C. by adding hot or cold water to the water bath, always stirring the sample well until a uniform temperature is secured. This is imperative. The sample may be stirred by rotating the sample cup frequently. It may also be stirred by lifting the spindle from the points *p* and stirring with the disk *G* holding the spindle by the barrel *E* and stirring by giving the disk an up-and-down movement in the sample cup. In the case of compounds, it is necessary to stir in this manner. In testing varnishes and oils, usually sufficient stirring can be obtained by rotating the cup while holding the barrel *E* to keep the disk stationary. If the spindle is removed from the points *p* it must always be suspended again with the same flat side of the supporting triangular button against the supporting arm so that the zero position is not changed.

If, when resuspending the spindle from points *p* it is noted that the zero point has moved, do not reset the indicator *A* as the change probably is due to some torsional effect produced by the sample. This may be especially noticed when testing compounds. Rotate the cup and take the reading without resetting the indicator.

When reading the thermometer have the bulb in the sample midway between the disk and the container wall and not resting on the bottom. Test the temperature at various points in the container to determine if a uniform temperature has been secured.

When a uniform temperature of 21° C. is secured, start the cup rotating by closing the switch *R*. Keep a hand on the switch and watch the scale on the disk *D*. If there is any danger that the deflection will go beyond the maximum limit for the suspension being used, open the switch immediately. Insert the next strongest wire suspension into the spindle and repeat as above indicated. When changing suspensions it is necessary to again set for zero. This may be accomplished without removing the sample, by simply removing the water bath, *I*, with its sample container, *H*, and then suspending the spindle with its new suspension on *p*, and leveling and adjusting as described above. It is necessary, of course, to thoroughly clean the disk, *G*, when doing this for if any varnish film should dry on the disk, the uneven or rough surface thus produced on the disk would cause an erroneous reading. A suspension wire should never be allowed to deflect beyond its maximum limit, for beyond this point a permanent set would be produced in the wire and a new calibration of the wire would have to be made or probably a new wire would have to be used. Table I gives a maximum and minimum limit for suspensions now in use. If the deflection is less than this minimum limit the next weakest suspension must be inserted and the test repeated. The reason for this is that at low deflections a change in slope appears on the calibration curve of the MacMichael degrees *versus* centipoises. The percentage error is magnified here and hence a reading that comes up higher in the calibration curve should be used. The maximum limit given may not be the limit to which it is permissible to deflect the wire in order to prevent its acquiring a permanent set. It, however, happens to be the limit of the calibration curve available for that suspension when the wire was calibrated.

TABLE I—MAXIMUM AND MINIMUM LIMITS FOR SUSPENSIONS.

SUSPENSION NUMBER (B. & S. Gage No.)	MINIMUM DEFLECTION, DEG. MACMICHAEL	APPROXIMATE EQUIVALENT CENTIPOISE READING	MAXIMUM DEFLECTION, DEG. MACMICHAEL	APPROXIMATE EQUIVALENT CENTIPOISE READING
30 (Weakest)	30	18	125	89
28	20	35	100	200
26	7.5	30	35	175
24	5	70	32.5	400
22	10	200	45	975
21	5	225	40	1800
20	10	750	50	4200
18	4	700	24	4000
16	2	750	11	4000
14 (Strongest)	1	1375	5	5500

Record the deflection in degrees MacMichael and read the viscosity in centipoises from the calibration curve of the suspension used.

NOTE 1.—Before any sets of suspensions are used, they must be calibrated as noted under heading "Calibration of Suspensions."

NOTE 2.—The following table gives the diameter of the wires (new American music wire gage) used in making the suspensions and the maximum limit of torsion in degrees MacMichael to which they may be subjected before they acquire a permanent set:

SUSPENSION NUMBER (B. & S. Gage No.)	DIAMETER WIRE, IN.	TORSIONAL LIMIT, DEG. MACMICHAEL
30 (Weakest)	0.0100	125
28	0.0126	118
26	0.0159	110
24	0.0201	102
22	0.0254	92
21	0.0285	81
20	0.0320	73
18	0.0403	55
16	0.0508	35
14 (Strongest)	0.0641	5

NOTE 3.—Not all of the suspension noted above are required in testing varnish. Suspensions 22, 21 and 20 will be sufficient for practically all varnishes. The heavier wires 18, 16 and 14 are used for very viscous materials.

CALIBRATION OF SUSPENSIONS.

In order to calibrate the torsion wire suspensions used in this apparatus to measure viscosity, a number of samples of oil and a sample of pure castor oil should be prepared and sent to the U. S. Bureau of Standards for determination of absolute viscosity at various temperatures. The following are typical data as supplied by the Bureau of Standards on four standard samples of oil:

OIL SAMPLE	TEMPERATURE, DEG. CENT.	VISCOSITY, CENTIPOISES
No. 1. Mineral Oil (Transformer) 63 seconds Saybolt viscosity at 100° F	10	29.95
	20	18.6
	30	12.44
No. 2. Mineral Oil (Transformer) 104 seconds Saybolt viscosity at 100° F	10	72.50
	20	41.02
	30	25.40
No. 3. Mineral Oil (Lubricating) 297 seconds Saybolt viscosity at 100° F	10	405
	20	169.9
	30	89.64
No. 4. Castor Oil, U. S. P. (AA)	10	2693
	15	1704
	20	1104
	25	746

The viscosity of sample No. 1 is so low that even with the weakest suspension only a very small deflection is secured. As the percentage of error is higher at small deflections than at large deflections, such a sample should not be used. These samples must have their absolute viscosities checked at least once a year as it has been found that the oils undergo some change on standing over long periods.

The calibration of the wires is made by testing the standardized samples of oil, following the directions as given above under heading "Directions for Making Viscosity Measurement on Varnishes." Tests are made at the same temperatures as used by the Bureau of Standards for their absolute viscosity tests. The above standard samples would be used as follows:

	SUSPENSION NUMBER
Sample No. 2 at 10° C.—20° C.—30° C.	30, 28, 26, 24, 22 and 21
" " 3 " 10° C.—20° C.—30° C.	21
" " 3 " 20° C.—30° C.	26, 24, 22 and 21
" " 4 " 10° C.	18, 16 and 14
" " 4 " 15° C.	20, 18, 16 and 14
" " 4 " 20° C.	21, 20, 18 and 16
" " 4 " 25° C.	21, 20, 18 and 16

The degrees MacMichael obtained for each suspension on each sample at each temperature are plotted against corresponding U. S. Bureau of Standards absolute viscosity figures (centipose) for those samples at the same temperatures and a line is drawn through these points. The line should be straight except possibly at low deflections where the error is correspondingly high.

Once every two months the suspensions should be recalibrated. In this recalibration the viscosities obtained as read from the plotted curve are compared with the Bureau of Standards viscosities and if they agree within 10 per cent, the curve need not be replotted. In cases of low viscosities 15 per cent error is allowable. If the majority check tests show a larger error, a new curve should be plotted for the suspension.

APPENDIX II

DIELECTRIC STRENGTH TESTS ON COPPER BASE

Where it is desired to make dielectric strength tests of solid films of varnish (as distinguished from the specimens prescribed in the methods, which are a combination of varnish and paper fibers), it is recommended that copper be used as the base as formerly required in the methods. The following are the directions for preparing and testing such specimens:

1. (*a*) Specimens are prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which is at the consistency prescribed in Section 5 (*b*) of the methods.

(*b*) Each specimen is dipped twice, once in each direction, in order to give a more uniform thickness of coating. The specimen is dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish are dried in free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period six times as long as that determined in accordance with Section 7 of the methods.

(*d*) Specimens of baking varnish are drained and then baked after each dip for a period three times as long as that determined in accordance with Section 7 of the methods.

(*e*) The final thickness of the film of varnish on each side of the specimen is between 0.044 mm. (0.0018 in.) and 0.052 mm. (0.002 in.).

2. (*a*) The dielectric strength of the two films of varnish is determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased at a rate of approximately 0.5 kv. per second. The electrodes shall be polished and cleaned after each puncture. As the temperature of the electrodes increases after a number of tests, it is advisable to change the electrodes after every twenty punctures. Ten such punctures are to be made at various points selected at random on each specimen. After testing, the thickness of the specimen shall be determined by making five measurements on a strip cut diagonally across the specimen. The measurements shall be equally spaced along the strip except in the case of a measurement being to close to a point of puncture. The average of the five measurements shall be considered as the thickness of the specimen.

NOTE.—When necessary, in order to get ten punctures, additional specimens should be tested.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 100 volts. The apparatus shall comply with the Standards of the American Institute of Electrical Engineers.

3. The volts at puncture, the net thickness of insulation and the volts per mil of net thickness shall be reported for each of the ten tests together with the average maximum and minimum volts per mil.

TENTATIVE METHODS OF TESTING SHEET AND TAPE INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

A.S.T.M. Designation: D 149 – 31 T

This is a **Tentative Standard**, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1922; Revised, 1923, 1924, 1926, 1927, 1930, 1931.

Scope.

1. These methods are designated to determine the dielectric strength of sheet and tape insulating materials except (*a*) rubber insulating tape, which should be tested in accordance with the Tentative Specifications for Rubber Insulating Tape (A.S.T.M. Designation: D 119 – 28 T) of the American Society for Testing Materials,[2] and (*b*) friction tape for electrical purposes which should be tested in accordance with the Standard Specifications for Friction Tape for General Use for Electrical Purposes (A.S.T.M. Designation: D 69) of the American Society for Testing Materials.[3]

Since the dielectric strength of sheet and tape materials is dependent upon the time of application of the electrical tension, two tests differing in time duration are included as *A*, Short-Time Dielectric Strength Test, and *B*, One-Minute Step-by-Step Dielectric Strength Test, respectively.

A third test, designated as an Endurance Dielectric Strength Test, is included under *C*. It shows the relative dielectric strength of different flexible sheet and tape insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

It should be noted that the results obtained with the electrodes specified for sheet material will differ from those specified for tape material (Section 3) and will not be comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes.

Sheet materials are divisible into two general classes: (1) thin, flexible materials, easily bent or wrapped around conductors, and (2) laminated materials, slightly flexible or rigid.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1068 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 765.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1036.

Tests on thin flexible materials at room temperature shall be made in accordance with Method *A* Short-Time Dielectric Strength Tests as specified in Sections 2 to 12; with Method *B* One-Minute Step-by-Step Dielectric Strength Test as specified in Sections 13 to 22, or with Method *C* Endurance Dielectric Strength Test as specified in Sections 23 to 28.

Tests on laminated sheet materials at room temperature shall be made in accordance with the special instructions covered under Dielectric Strength Tests on Laminated Materials in Sections 29 to 32.

A. Short-Time Dielectric Strength Test

APPARATUS

High-Voltage Transformer. 2. (*a*) Any well-designed, high-tension transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high-tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

Electrodes.

3. The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).

TEST SPECIMENS

Test Specimens.

4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

PROCEDURE

Surrounding Medium.

5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes.

6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen.

7. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage.

9. Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kv. per second, except that if break-

down occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will occur in not less than 40 seconds. If the material fails at less than 5 kv., the minimum time shall be reduced from 40 seconds to 20 seconds.

Number of Tests. 10. Ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness. 11. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 12. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

APPARATUS

Apparatus. 13. The apparatus shall consist of the high-voltage transformer and the electrodes specified in Sections 2 and 3.

TEST SPECIMENS

Test Specimens. 14. The test specimens shall be as specified in Section 4.

PROCEDURE

Surrounding Medium. 15. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes. 16. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 17. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

18. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage. 19. An initial voltage shall be applied equal to 40 per cent of the breakdown voltage in the short-time test, adjusted as shown in the following table. The voltage shall then be increased in increments as indicated in the table, up to failure, being held at each step for one minute. The change from each step to the next higher shall be made within 10 seconds.

BREAKDOWN KILOVOLTS BY SHORT-TIME METHOD	ADJUST 40 PER CENT OF BREAKDOWN VOLTAGE TO NEAREST	INCREMENT OF INCREASE
12.5 kv. or less	0.5 kv.	0.5 kv.
over 12.5 to 25 kv., inclusive	1.0 "	1.0 "
over 25 " 50 " "	2.5 "	2.5 "
over 50 " 100 " "	5.0 "	5.0 "
over 100 "	10.0 "	10.0 "

NOTE.—*Example:*

Breakdown voltage by short-time method = 41 kv.
40 per cent of breakdown voltage = 16.4 kv.
Initial voltage obtained by adjusting 40 per cent of breakdown voltage to nearest 2.5 kv. = 17.5 kv.
Voltage will be increased in increments of 2.5 kv.
Therefore, second step = 20.0 kv., etc.

Number of Tests.

20. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness

21. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report

22. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test;

(*g*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

APPARATUS

Apparatus.

23. The apparatus shall consist of the high-voltage transformer specified in Section 2.

Test Specimen

24. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets, on brass tubes. The tubes shall be, for sheets and for tape up to $1\frac{1}{2}$ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than $1\frac{1}{2}$ in., the tubes shall be 2 in. in outside

diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction.

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape which shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

PROCEDURE

Position of Specimen. 25. The specimen shall be mounted in an oven and a temperature of 100° C. (212° F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground.

Application of Voltage. 26. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Method *A*) shall be applied and maintained for 30 minutes. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 minutes.

Temperature Readings. 27. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-minute period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals.

Report. 28. (*a*) The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with time. The significant values to be taken from the curve and reported are:

(*1*) Duration of test;
(*2*) Breakdown voltage;
(*3*) Temperature of specimen at breakdown;
(*4*) Rate of temperature rise during test.

(*b*) The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.

Dielectric Strength Tests on Laminated Materials:

29. For testing laminated sheet materials the procedure described in Method A, Short-Time Tests, Sections 2 to 12 and Method B, Step-by-Step Test, Sections 13 to 22 shall be modified in accordance with Sections 30 to 32.

Surrounding Medium.

30. All tests shall be made under oil maintained at normal room temperature.

Position of Electrodes and Specimen.

31. Tests may be transverse or parallel to the laminations, or both, depending upon whether the stress on the material when in use is to be transverse or parallel to the laminations, or both.

(*a*) Transverse tests shall be made between the standard 2-in. electrodes (Section 3).

NOTE.—Surface creepage and flashover at the higher voltages may be prevented by puring around the electrodes any high-grade insulating compound which will form a good bond with the material and with the electrodes. Sealing wax and phenolic resin varnish have been successfully used under certain conditions. In applying this protective compound, care must be taken to prevent voids under the edges of the electrodes.

(*b*) For tests parallel to the laminations, the material shall be cut into sections 2 in. square. Holes shall be drilled into opposite edges of each section so as to line up with each other, the inner ends of the holes being ½ in. apart. Metal electrodes shall be used, the ends of which exactly fit the ends of the holes. Thus, in effect, the material is tested edgewise in a modified needle gap. The diameter of hole should be approximately one-fourth the thickness of the specimen. For very thin specimens it may be necessary to use a larger ratio of drill size. Results shall be expressed in total kilovolts breakdown.

Number of Tests.

32. For the Short-Time Method five tests shall be sufficient, and for the Step-by-Step Method three tests.

Tests on Both Thin and Laminated Materials at Different Temperatures:

33. Where the test materials are to be used at other than room temperature, their dielectric strength characteristic should be ascertained over the operating range of temperature.

Apparatus.

34. Temperature control shall be obtained by the use of an air oven (or refrigerator) in the case of thin materials, or by the use of an oil bath, in the case of laminated materials.

(*a*) The air oven should be provided with some means of circulating the air, so that approximately constant temperature is maintained around the test specimen, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable. Any well-designed oven of sufficient size to hold the test equipment is satisfactory for this purpose.

(*b*) The oil bath should be provided with some means for circulating the oil, so that the temperature is substantially uniform around the test specimens, and with a thermometer or thermocouple for measuring the temperature as near the point of test as practicable.

Procedure. 35. The test material shall be subjected to the test temperature, before voltage is applied, for a period in minutes equal to half the thickness of the specimen in mils.

The tests shall cover the operating range of temperature to which the test material is to be subjected. Where this range is considerable, tests should be made at not less than four points, so that a curve of dielectric strength (volts per mil) against temperature may be plotted. These points should include the maximum and minimum operating temperatures. The number of tests at each temperature shall be as specified in Sections 10 and 32.

APPENDIX

Figure 1 shows the multiple electrode form of tape tester. In this type, a strip of tape is held between four impregnated wooden blocks, *A*, which are in turn held in place in the two main blocks, *B*, by means of the thumb screws *C* in the ends of the blocks *A*. The blocks *A* are wound butt jointed with 1-in. varnished cloth tape. The whole device is clamped tightly together by the six thumb screws *D*.

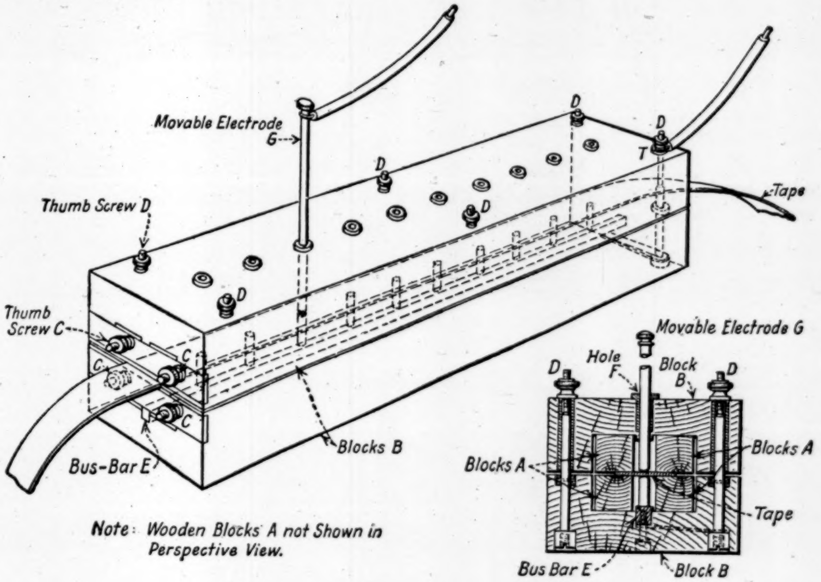
There are ten lower electrodes which are fixed to a common bus-bar *E* The upper electrode, *G*, is movable and may be inserted into any of the bushed holes *F* which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus-bar *E* through the thumb-screw terminal *D* marked *T*. The electrodes are cylindrical brass rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until ten punctures have been obtained

As more or less carbon is formed during tests, the successful operation of this device depends upon keeping the parts clean. The electrodes should be cleaned with very fine emery paper, being careful not to change their form. The blocks *A* should be rewound from time to time with new varnished cloth tape.

Referring to Fig. 2 (*a*), the tape is held between two pieces of fiber, *A*, which, in turn, are held between two impregnated wood blocks, *B*, held in brass bases, *C*. The blocks are pressed together by a spring, *D*, which is compressed by the latch handle, *E*, through a rounded pin, *F*, fitting into a cup-shaped cap.

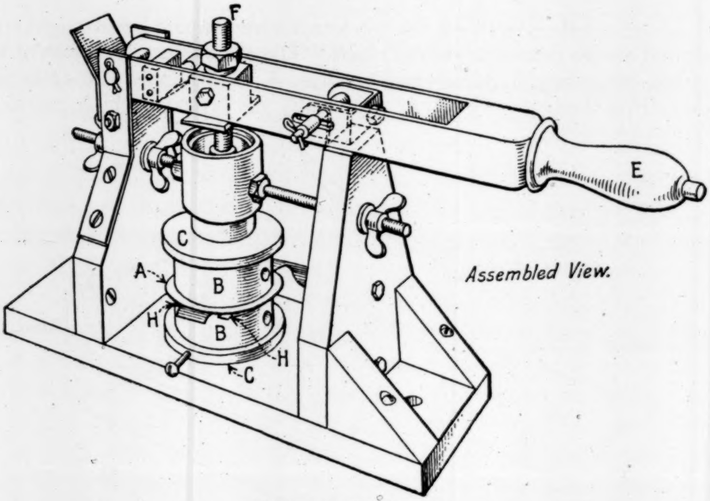
G. When the handle is released, the blocks are spread apart by two light springs, *H*, mounted on the face of the lower block. The electrodes, *J*, consist of hollow rods, fitted with very light internal springs, *K*, which hold the ends against the tape during the test. Vents, *L*, relieve any gas pressure which may develop when puncture occurs.


Movable Electrode G
D
D
T
D
Tape
D
Thumb Screw D
D
Thumb Screw C
C
C
C
Bus-Bar E
Blocks B
Movable Electrode G
Hole F
Block B
D
D
Blocks A
Blocks A
Tape
Bus Bar E
Block B

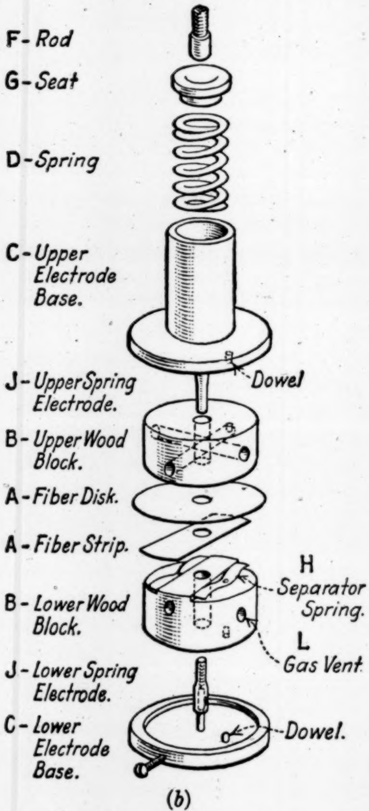
Note: Wooden Blocks A not Shown in Perspective View.

Fig. 1.—Apparatus for Dielectric Strength Test on Tape.

After considerable use, a leakage path will develop along the surface of one of the blocks and re-surfacing becomes necessary. This condition is avoided by using fiber disks as indicated in Fig. 2 (*b*). These disks are easily removed and replaced as necessary.


F
E
C
A
B
H
B
H
C
Assembled View.

(*a*) **Assembled View.**


F - Rod
G - Seat
D - Spring
C - Upper Electrode Base.
Dowel
J - Upper Spring Electrode.
B - Upper Wood Block.
A - Fiber Disk.
A - Fiber Strip.
H
Separator Spring.
B - Lower Wood Block.
L
Gas Vent
J - Lower Spring Electrode.
C - Lower Electrode Base.
Dowel.

(*b*)

FIG. 2.—Lever Operated Form of Tape Tester.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING MATERIALS FOR POWER FACTOR AND DIELECTRIC CONSTANT AT FREQUENCIES OF 100 TO 1500 KILOCYCLES[1]

A.S.T.M. Designation: D 150 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1922; Revised, 1923, 1927, 1931.

Scope. 1. These methods provide for the determination of the power factor and dielectric constant of solid electrical insulating materials at frequencies of 100 to 1500 kilocycles.

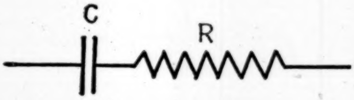


Fig. 1.—Equivalent Series Circuit.

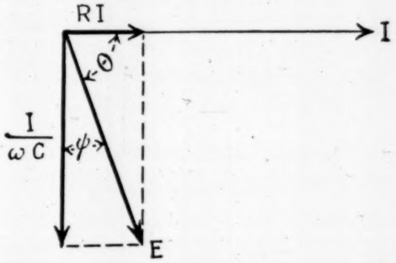


Fig. 2.—Vector Diagram for Equivalent Series Circuit.

DEFINITIONS

Power Factor. 2. *Power Factor.*—The power factor of an insulating material is the ratio of the total power loss (watts) in the material to the product of voltage (volts) and current (amperes) in a capacitor in which that material is the dielectric.

Dielectric Constant. 3. *Dielectric Constant.*—The dielectric constant of an insulating material is the ratio of the capacitance of a capacitor in which that material is the dielectric to the capacitance of a similar capacitor in which the dielectric is a vacuum. (For practical purposes air dielectric is equivalent to a vacuum.)

Loss Factor. 4. *Loss Factor.*—For the purpose of these methods the loss factor of an insulating material is the product of its power factor and its dielectric constant.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

THEORY OF TEST

Power Factor.

5. (*a*) *Series Notation.*—Any insulating material between two electrodes constitutes a capacitor. Such a physical capacitor may be represented by a capacitance C and a resistance R in *series* as shown in Fig. 1. The resistance R is called the equivalent series resistance and the capacitance C is called the equivalent series capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 2. The power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1} R\omega C$$

where R = the resistance in ohms;
ω = 2π times the frequency in cycles; and
C = the capacitance in farads.

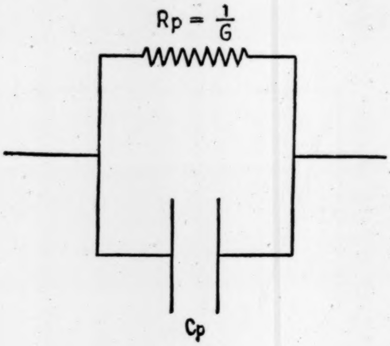

FIG. 3.—Equivalent Parallel Circuit.

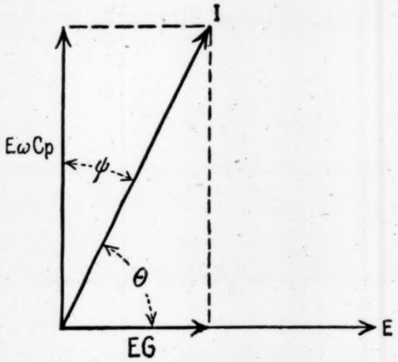

FIG. 4.—Vector Diagram for Equivalent Parallel Circuit.

Since, for small angles the sine is substantially equal to the tangent, the power factor equals $R\omega C$, approximately. This is correct to closer than 0.5 per cent of the power factor value for power factors up to 0.1. Where R is expressed in ohms, C in micromicrofarads and the frequency, f, in kilocycles, this expression becomes:

$$\text{Power Factor} = 6.28\, RCf \times 10^{-9}$$

The power factor is, therefore, determined by measuring the values of R and C. This may be done by the Substitution Method as described in Sections 14 and 15.

(*b*) *Parallel Notation.*—A physical capacitor may also be represented by a capacitance C_p and a resistance R_p in *parallel* as shown in Fig. 3. The resistance R_p is called the equivalent parallel resistance and the capacitance C_p is called the equivalent parallel capacitance of the capacitor. For sine-wave voltage and current the vector relations are as shown in Fig. 4. For this notation the power factor is:

$$\text{Power Factor} = \cos\theta = \sin\Psi = \sin\tan^{-1}\frac{G}{\omega C_p}$$

where G = the conductance in *mhos;*
ω = 2π times the frequency, in cycles; and
C_p = the capacitance in farads.

Making the same approximations as in Paragraph (*a*), the power factor for practical purposes is taken as $\frac{G}{\omega C_p}$. Where G is expressed in micro-mhos, the frequency, f, in kilocycles, and C_p in micro-microfarads, this expression becomes:

$$\text{Power Factor} = 1.59\,\frac{G\,10^2}{fC_p}$$

It will be seen that G and C_p determine the power factor. They may be measured by the Bridge Method as described in Sections 19 and 20.

The equivalent series capacitance C as determined by the Substitution Method, Sections 14 and 15, and the equivalent parallel capacitance C_p as determined by the Bridge Method, Sections 18 and 19, are not identical; but for power factors up to 0.1 they are equal to within 1 per cent. Either value may be used in calculating the dielectric constant.

Dielectric Constant.

6. (*a*) *Sheet Materials.*—For sheet materials, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{(C - C_e)t}{0.0885A}$$

where t = the average thickness of dielectric between electrodes, in centimeters;
A = the contact area of either of the equal electrodes in square centimeters;
C = the measured capacitance in micro-microfarads;
C_e = the edge correction obtained from the curve in Fig. 5.[1]

The determination of C_e requires a knowledge of the approximate value of K which can always be obtained by making a preliminary calculation, neglecting C_e in the above formula. For thickness t, in inches, and area A, in square inches, the above formula becomes:

$$\text{Dielectric constant, } K = \frac{(C - C_e)\,t}{0.224\,A}$$

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[1] For details of the determination of the edge correction, see E. L. Hoch, *Bell System Journal*, Vol. V. pp. 555-572c, October, 1926.

(*b*) *Tubes.*—For materials in the form of tubes, the dielectric constant, K, may be calculated from the following formula:

$$\text{Dielectric constant, } K = \frac{3.6\, t\, (C_1 - C_2)}{D\, (l_1 - l_2)}$$

where t = the thickness of the tube in centimeters;
D = the mean diameter in centimeters;
C_1 = the measured capacitance in micro-microfarads when the electrodes have a length of l_1 centimeters; and
C_2 = the measured capacitance in micro-microfarads when the electrodes have a length of l_2 centimeters.

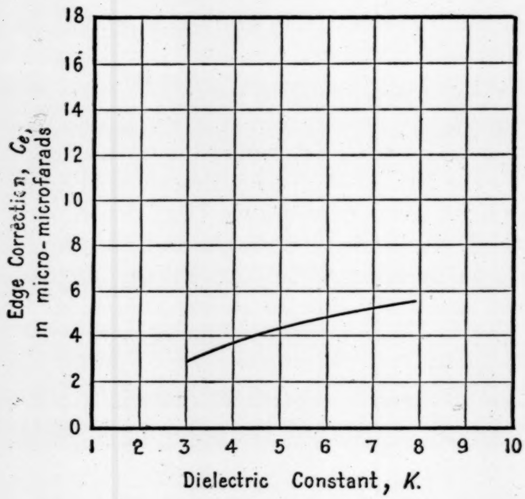

Fig. 5.—Edge Correction Curve for 4.5-in. Diameter Electrodes.

Note.—The two measurements C_1 and C_2 are made with different electrode lengths l_1 and l_2 for correction of edge effect.

If the tube thickness is so small, or the electrode length so large that the edge correction may be neglected, then the dielectric constant, K, may be calculated from the following:

$$\text{Dielectric constant, } K = \frac{3.6\, t\, C}{D\, l}$$

where C = the measured capacitance in micro-microfarads for electrodes of length l centimeters.

Loss Factor. 7. The total power loss per unit volume of insulating material for a stated frequency, voltage gradient, and temperature, is proportional to the product of the power factor and dielectric constant. Therefore, the loss factor is defined as:

Loss Factor = Power Factor × Dielectric constant, K

TEST SPECIMENS

Test Specimens.

8. (*a*) *Molded or Sheet Materials.*—For testing molded or sheet materials the test specimen shall be either a disk 6 in. (15.24 cm.) in diameter or a square 6 in. (15.24 cm.) on a side. The thickness shall preferably not be less than 0.1 in. (0.254 cm.) nor more than 0.3 in. (0.762 cm.). The thickness shall be uniform to ±5 per cent, and the surfaces shall be smooth and free from irregularities. Other thicknesses may be used where it is desired to test materials of the various thicknesses in commercial use. In any case, the capacitance of the specimen shall preferably not be less than 100 micro-microfarads.

(*b*) *Films.*—For testing films of insulating varnish, lacquer, or paints, the test specimen shall be prepared as specified for the dielectric strength tests in Appendix II to the Tentative Methods of Testing Varnishes Used for Electrical Insulation (A.S.T.M. Designation: D 115 - 31 T) of the American Society for Testing Materials.[1] The copper or brass plate shall be one capacitor plate, and tin-foil the other. Both varnish films may be tested individually.

(*c*) *Tubes.*—For testing rolled or molded laminated tubes, the test specimen shall have the diameter and wall thickness of the material it represents, and shall be of sufficient length to provide a capacitance of not less than 100 micro-microfarads. The thickness shall be uniform to ± 5 per cent, and the surfaces shall be smooth and free from irregularities.

Conditioning of Test Specimens.

9. Before the specimens are tested, they shall be kept for 48 hours under uniform atmospheric conditions. Unless otherwise specified, these conditions shall be a relative humidity of 60 per cent and a temperature of 20 to 30° C. A satisfactory method of maintaining constant humidity is given in Section 13 of the Tentative Methods of Test for Resistivity of Insulating Materials (A.S.T.M. Designation: D 257 - 29 T) of the American Society for Testing Materials.[2]

Electrodes.

10. (*a*) *Molded or Sheet Materials.*—The electrodes shall consist of tin or lead-foil disks 4.5 in. (11.43 cm.) in diameter and approximately 0.001 in. or 0.002 in. (0.025 or 0.050 mm.) in thickness. They shall be applied to the surface of the specimen and shall be accurately centered with respect to each other and approximately with respect to

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[1] See p. 866.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 29, Part I, p. 773 (1929); also 1931 Book of A.S.T.M. Tentative Standards, p. 693.

the specimen. A very thin coating of petrolatum shall be used as an adhesive.

(*b*) *Films.*—For testing materials of thickness less than 0.1 in. (0.254 cm.), such as thin-sheet insulating materials and films of insulating varnish and lacquer, the electrode area may be adjusted to give any convenient capacitance above 100 micro-microfarads. When calculating the dielectric constant of such materials, the edge correction should be omitted.

(*c*) *Tubes.*—The outer electrode shall consist of tin or lead foil. The inner electrode shall consist either of tin or lead foil, or of mercury. The electrodes shall completely cover the tube surfaces to within ¼ in. of the ends of the specimen, shall be centered approximately with respect to the length of the specimen, and shall be located exactly opposite each other.

NOTE.—A very thin coating of petrolatum is a good adhesive for the foil. A cork or a wax plug provides means for holding the mercury in the tube.

PROCEDURE

Method. 11. (*a*) The method of measurement may be either the substitution method as described in Sections 12, 13, 14 and 15, or the Bridge method as described in Sections 16, 17, 18, 19 and 20.

Measurements. (*b*) The power factor and dielectric constant of at least two specimens shall be measured at such frequencies as may be mutually agreed upon between the supplier and the purchaser. Unless otherwise agreed upon the frequencies shall be approximately 100 kilocycles and 1000 kilocycles.

A. Substitution Method

APPARATUS

Generating Circuit. 12. *Oscillator.*—The generating circuit for the Substitution Method shall consist of an oscillator (preferably a vacuum tube) which is the power source. This oscillator shall be designed so as to be easily adjustable over a range of frequencies from 100 to 1500 kilocycles, and shall have a power rating sufficient to prevent any reaction on frequency or voltage output when coupled to the measuring circuit. The oscillator output shall be of approximately sine-wave form, having not more than 5-per-cent harmonic components. The oscillator shall be well shielded. The entire apparatus shall be installed in a well-shielded room or so located as to be free from interference.

13. The measuring circuit is shown in Fig. 6 and shall consist of the following parts: **Measuring Circuit.**

Coupling Coils.—Several coupling coils so designed as to tune over the required frequency range to within 1 per cent of the frequency desired. For convenience in tuning, an adjustable air capacitor of about 0.001 micro-farads capacity (tuning capacitor) may be connected across the coupling coil. This tuning capacitor should be of the same sensitivity of adjustment as the standard air capacitor, but no calibration is necessary.

Capacitor.—An adjustable standard air capacitor having a capacitance of about 0.001 microfarad capable of being read to 0.5 micromicrofarad. This capacitor shall be calibrated for capacitance and power factor over the required frequency range.

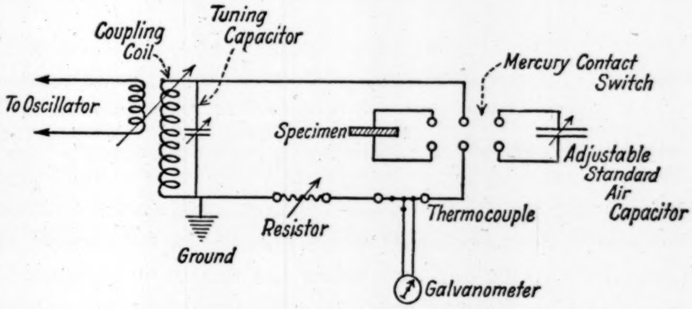

FIG. 6.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method.

Switch.—A special high-frequency switch of the mercury contact type having mercury cups mounted on Pyrex or quartz tubes 4 to 6 in. (10 to 15 cm.) in length. This switch shall be a double-pole, double-throw, with copper switch blades well amalgamated with mercury.

Thermocouple Galvanometer.—The thermocouple shall have a low heater resistance, preferably less than 2 ohms, and be sufficiently sensitive for use with a suitable galvanometer. The galvanometer shall be of low resistance and short period and shall be operated critically damped. It shall have a sensitivity of approximately 120 mm. per micro-ampere at a scale distance of 1 meter.

Resistors.—Several resistors made of short, straight lengths of non-magnetic resistance wire (advance or manganin is preferable) sealed into glass tubes (which may be evacuated if desired). These resistors shall all have approximately the same length. For most work, 30 resistors to cover a range of 0.2 to 60 ohms will suffice. When resistance values higher than 60 ohms are required, a 3-dial 1000-ohm non-reactive decade box may be used.

METHOD

Operation.

14. (*a*) *Procedure.*—With the specimen connected to the measuring circuit through the mercury contact switch, the circuit shall be tuned to approximately the desired frequency by proper selection of the coupling coil. The circuit may be brought into exact resonance by adjusting the frequency of the oscillator, or by means of the tuning capacitor if the latter is used. Resonance is indicated by maximum deflection of the galvanometer. The coupling to the oscillator shall be varied at the same time so that with no resistance inserted in the measuring circuit, approximately a two-third scale deflection of the galvanometer is obtained.

The adjustable standard air capacitor and a resistor shall then be substituted for the specimen. The resistance should be so chosen that when the measuring circuit is tuned to resonance by adjusting the standard air capacitor, a maximum deflection will be obtained on the galvanometer which is approximately the same as that previously produced by the specimen. Four resistors shall then be chosen having resistance values such that when inserted in the circuit, two will give deflections above and two below the deflection produced by the specimen. The deflections obtained with these four resistors shall be plotted against their resistance values. From this curve the equivalent series resistance R of the specimen shall be obtained by reading the value of resistance corresponding to the deflection produced by the specimen and adding to it the value of the resistance of the standard capacitor at the capacitance and test frequency used.

When a decade resistor is used, the procedure is the same as above except that it is sufficient to adjust the resistor to obtain a deflection equal to that produced by the specimen. The equivalent series resistance R is then equal to the dial reading of the resistance box plus the resistance of the standard air capacitor at the capacitance and test frequency used.

The capacitance reading of the standard air capacitor corrected for lead capacitance is the equivalent series capacitance C of the specimen.

The frequency shall be determined after the final tuning.

(*b*) *Alternative Procedure.*—The circuit for the alternative substitution method is shown in Fig. 7 and consists of a coupling coil, capacitor, switch, thermocouple galvanometer, and resistors as for the Substitution Method and conforming to the requirements of Section 13.

The standard capacitor shall be tuned to resonance, first, with the specimen in parallel and then alone in the circuit. The manipulation and calculations shall be made as follows: With the resistance, R, set to zero and the specimen, C_x, in parallel with the adjustable standard air capacitator, C_s, tune C_s to resonance, read the value of C_s (equals C_1) and the galvanometer deflection d_1. Disconnect the specimen and tune C_s to resonance and read (equals C_2), add resistance R_1, to make galvanometer deflection equivalent to d_1, calculate C_x and R_x from the following formulas:

$$C_x = C_2 - C_1$$

$$R_x = R_1 \left(\frac{C_2}{C_x}\right)^2$$

The power factor shall be calculated from the following formula:

$$\text{Power Factor} = 2\,\pi f\, C_x R_x$$

where f is expressed in cycles, C_x is expressed in farads and R_x is expressed in ohms.

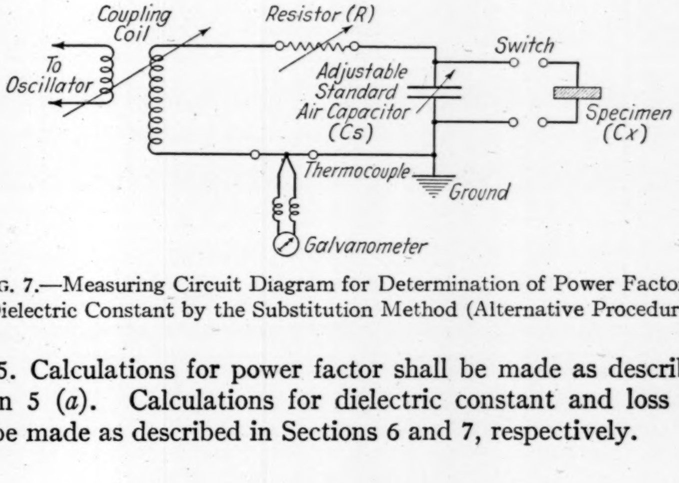

FIG. 7.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Substitution Method (Alternative Procedure).

15. Calculations for power factor shall be made as described in Section 5 (*a*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively. **Calculations.**

B. Bridge Method

APPARATUS

16. The generating circuit for the Bridge Method shall be the same as for the Substitution Method as described in Section 12. **Generating Circuit.**

NOTE.—The oscillator does not need to be of as high a power output for the Bridge Method as for the Substitution Method.

Measuring Circuit. 17. The measuring circuit is shown in Fig. 8 with necessary shielding as indicated, and shall consist of the following parts:

Balanced Resistors.—One pair of balanced non-reactive resistors or ratio arms, *AB* and *BC*, each of approximately 250 ohms resistance, and enclosed in an electrostatic shield as shown in Fig. 8. These arms shall be balanced for resistance to within 0.05 of 1 per cent, and for reactance to within 0.1-micro-microfarad equivalent parallel capacitance.

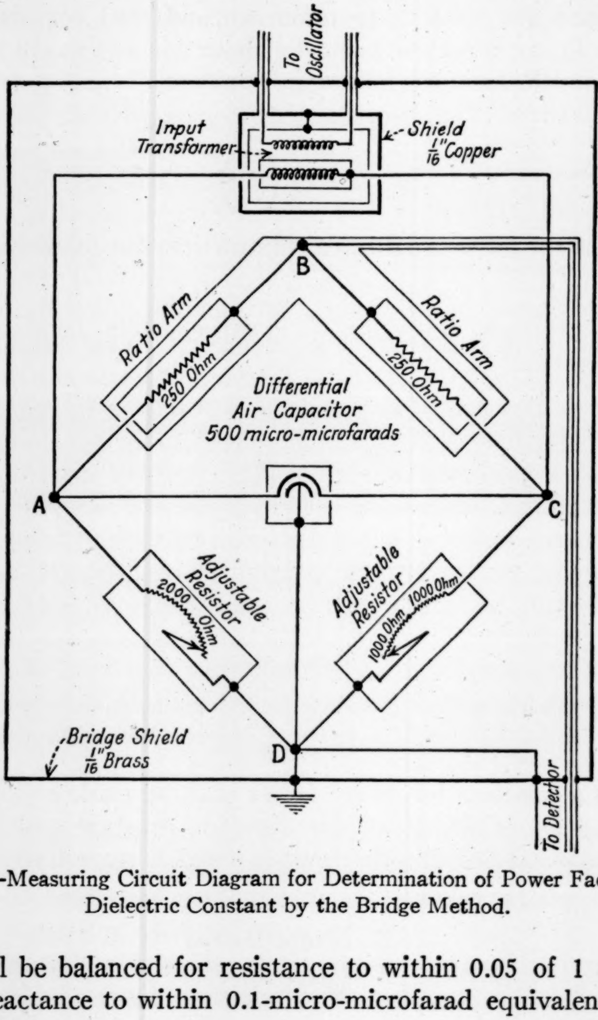
To Oscillator
Input Transformer
Shield $\frac{1}{16}$" Copper
B
Ratio Arm
250 Ohm
Ratio Arm
250 Ohm
Differential Air Capacitor 500 micro-microfarads
A
C
Adjustable Resistor
2000 Ohm
Adjustable Resistor
1000 Ohm
1000 Ohm
Bridge Shield $\frac{1}{16}$" Brass
D
To Detector

FIG. 8.—Measuring Circuit Diagram for Determination of Power Factor and Dielectric Constant by the Bridge Method.

Adjustable Resistors.—Two non-reactive adjustable resistors each shielded as shown, for use in the *AD* and *CD* arms of the bridge. The *CD* arm resistor shall comprise two 1000-ohm steps. The *AD* arm resistor shall be a four-dial decade box having steps of 0.1, 1, 10, and 100 ohms, with an additional 1000-ohm step. Precision type, high-frequency commercial resistances are satisfactory for use in these resistors.

Differential Air Capacitor.—One differential air capacitor of 500-micro-microfarad capacitance, total variation. For convenience it is desirable to provide a vernier capacitor adjustable to 0.01 micro-microfarad. These capacitors shall be calibrated to read the capacitance inserted in the *CD* arm.

Input Transformer.—One shielded input transformer[1] adapted to the connection of a 250-ohm impedance to the oscillator.

Detector Circuit.

18. The detector circuit shall consist of any suitable detector of sufficient sensitivity to indicate an unbalance of 0.1 ohm in the *AD* bridge arm. A heterodyne type used with a telephone receiver will be found satisfactory.

METHOD

Operation.

19. Suitable leads for connecting to the specimen shall be connected to terminals *C* and *D* of the bridge, Fig. 8, but not to the specimen. The bridge shall then be balanced by adjusting the differential air capacitor and the adjustable arm resistor *AD*. The capacitance and resistance values are then recorded as C_o and R_o. These readings shall be taken to compensate for the capacitance in the bridge and lead wires. The specimen shall then be connected to the lead wires, and the bridge balanced again. The capacitance and resistance values are recorded as C_1 and R_1. The equivalent parallel capacitance of the specimen is: $C_p = C_1 - C_o$, and the conductance $G = \frac{R_o - R_1}{R_o \times R_1}$. By properly adjusting the value of R_o, G can be made substantially equal to $R_o - R_1$ times some power of ten.

The frequency shall be determined when the bridge is finally balanced.

Calculations.

20. Calculations for power factor shall be made as described in Section 5 (*b*). Calculations for dielectric constant and loss factor shall be made as described in Sections 6 and 7, respectively.

ACCURACY

Accuracy.

21. The accuracy of the power factor and dielectric constant determinations by the above methods depend critically upon the care exercised in setting up the measuring equipment and in its sub-

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[1] For general features of such a transformer, see "A Shielded Bridge for Inductive Impedance Measurements at Speech and Carrier Frequencies," by W. J. Shackelton, *Journal*, Am. Inst. Electrical Engrs., February, 1927, p. 159.

sequent manipulation. The technique exercised in these respects shall be such that an accuracy within ±10 per cent for the determination of power factor, within ±5 per cent for the determination of the dielectric constant of sheets, and within ±10 per cent for the determination of the dielectric constant of tubes shall be obtained.

REPORT

Report. 22. The report shall include the following:

(*a*) The power factor, the dielectric constant, and the loss factor of each specimen.

(*b*) The following values for the specimen: the capacitance of the specimen in microfarads; effective area of the specimen; and the average thickness of the specimen between electrodes.

(*c*) The following test conditions: the frequency in kilocycles; temperature of the atmosphere in degrees Centigrade; relative humidity of the atmosphere in per cent; and the conditioning of the specimen (hours at humidity and temperature).

(*d*) A description of the material: that is, the name, grade, and color, and the name of the manufacturer.

(*e*) Method of measurement.

TENTATIVE METHODS OF TESTING LAMINATED SHEET MATERIALS USED IN ELECTRICAL INSULATION[1]

A.S.T.M. Designation: D 229 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1925; REVISED, 1926, 1928, 1930, 1931.

Scope. 1. These tests apply to laminated flat sheet materials intended for use as electrical insulation.[2]

Definition of Terms. 2. In referring to the cutting of the specimens and the application of the load, the following definitions apply:

Flatwise.—Load applied to the face of the laminations.
Edgewise.—Load applied to the edge of the laminations.
Lengthwise.—In the direction of the length of the sheet.
Crosswise.—In the direction at right angles to the length of the sheet.

NOTE.—When the sheet has the same length and width, one dimension shall arbitrarily be designated as the length, and the other as the width.

TENSILE STRENGTH

Apparatus. 3. Any standard type of testing machine may be used. The machine shall be accurate to within 1 per cent on the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens. 4. Tension test specimens shall conform to the dimensions shown in Fig. 1. The surfaces of the specimen shall be smooth and free from scratches.

Procedure. 5. Five specimens cut lengthwise and five specimens cut crosswise of the sheet shall be tested.

Temperature. 6. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 7. The cross-head speed of the testing machine shall be such that the load can be accurately weighed, but shall not exceed 0.05 in. per minute when the machine is running idle.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.

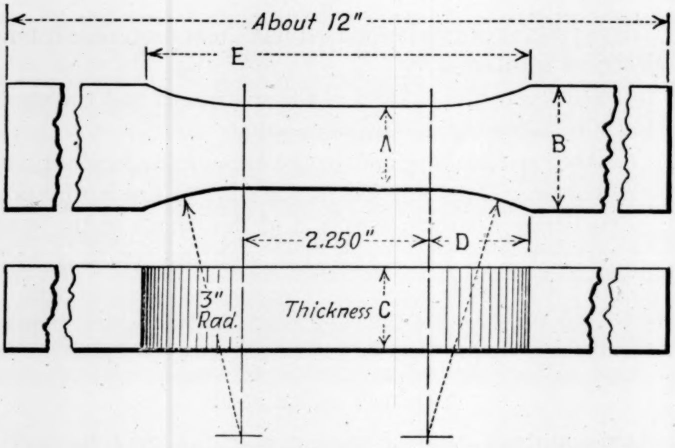
[2] Tests for shearing strength, compressive strength, moisture absorption, oil absorption and degree of curing are being studied by the committee. Various mechanical tests, particularly applicable to thin laminated sheet materials, are being developed.

Modulus of Elasticity. 8. When it is desired to determine the elongation under load, a suitable extensometer measuring the elongation on a 2-in. gage length shall be used. The cross-head speed of the testing machine shall not exceed 0.03 in. per minute when the machine is running idle.

Procedure. 9. The total change in length between zero load and a stress of 5000 lb. per sq. in. shall be determined.

Report. 10. The report shall include the following:

(*a*) The direction in which the specimen was taken, whether lengthwise or crosswise of the sheet.



When C is less than $\frac{1}{8}$ in., A is $\frac{1}{2}$ in., B is $\frac{3}{4}$ in., D is 0.857", E is 3.964 in.
When C is $\frac{1}{8}$ in. or over, A is 1 in., B is $1\frac{1}{2}$ in., D is 1.199", E is 4.648 in.

FIG. 1.—Tension Test Specimen for Laminated Sheet Insulating Materials.

(*b*) The thickness and width of each specimen in inches or centimeters.

(*c*) The breaking load of each specimen, in pounds or kilograms.

(*d*) The tensile strength of each specimen, in pounds per square inch or in kilograms per square centimeter.

(*e*) The location and nature of the fracture.

(*f*) The elongation in inches at a stress of 5000 lb. per sq. in., if determined.

(*g*) The room temperature.

FLEXURAL STRENGTH

(FORMERLY CALLED TRANSVERSE STRENGTH)

(A) For Materials $\frac{1}{32}$ in. Thick or Over[1]

Apparatus. 11. (*a*) Any standard type of testing machine may be used. The machine shall have an accuracy of at least 1 per cent of the lowest load for which it is used.

(*b*) The specimen shall be tested as a simple beam loaded at the center. The supports shall have contact edges rounded to a radius of $\frac{1}{8}$ in. for material $\frac{1}{8}$ in. or over in thickness, and to a radius of $\frac{1}{16}$ in. for thinner materials. For material thinner than $\frac{1}{8}$ in. both supports shall be provided with a pin or other stop to align one side of the specimen perpendicular to the line of contact with the supports. The distance between the points of support shall be 4 in. for edgewise tests of all thicknesses and eight times the nominal thickness of the material to be tested for tests in the flatwise direction, except that the minimum span shall be $\frac{1}{2}$ in.

Specimen. 12. The test specimen shall be $\frac{1}{2}$ in. in width except for specimens over $\frac{1}{2}$ in. in thickness tested in the flatwise direction, which shall have the width equal to the thickness of the specimen. The thickness shall be the full thickness of the sheet. The length shall be 1 in. greater than the distance between the points of support as specified in Section 11 (*b*).

Procedure 13. The specimens shall be tested as follows:

(*a*) Five specimens cut lengthwise of sheet, tested flatwise.
(*b*) Five specimens cut lengthwise of sheet, tested edgewise.
(*c*) Five specimens cut crosswise of sheet, tested flatwise.
(*d*) Five specimens cut crosswise of sheet, tested edgewise.

Temperature of Tests. 14. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 15. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 16. The report shall include the following:

(*a*) The directions of cutting and loading of the specimen as specified in Section 13.

(*b*) The thickness and width of each specimen in inches or millimeters.

(*c*) The breaking load of each specimen in pounds or kilograms.

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[1] Conventional flexure tests in a flatwise direction are not recommended for materials thinner than $\frac{1}{32}$ in. nor in the edgewise direction for materials thinner than $\frac{1}{4}$ in.

(*d*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter calculated from the formula:

$$S=\frac{3}{2}\frac{Pl}{bd^2}$$

where S = maximum fiber stress;
P = breaking load in pounds or kilograms;
l = distance between supports in inches or centimeters;
b = width of specimen in inches or centimeters;
d = depth of specimen in inches or centimeters.

(*e*) The room temperature.

COMPRESSIVE STRENGTH

Apparatus. 17. Any standard testing machine may be used provided it is accurate within 1 per cent of the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable, at the top, and the metal bearing plates shall be directly in contact with the ends of the test specimen. The pressure heads used for standard compression tests of cement as described in the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (A.S.T.M. Designation: C 9 – 16 T) of the American Society for Testing Materials[1] are satisfactory for this test.

Specimen. 18. (*a*) For sheets 1 in. in thickness or over, the test specimen shall be a 1-in. cube, the faces of which shall be flat and perpendicular to the axes, being ground to this condition if necessary.

(*b*) For sheets less than 1 in. in thickness, the specimen shall consist of a pile of sheets 1 in. square with a minimum number of layers to produce a height of at least 1 in.

Procedure. 19. (*a*) For sheets 1 in. in thickness or over, three specimens shall be crushed in the condition in which they are received with the load applied flatwise, three specimens with the load applied edgewise-lengthwise of the sheet and three specimens with the load applied edgewise-crosswise of the sheet.

(*b*) For sheets less than 1 in. in thickness, three specimens shall be crushed in the condition in which they are received with the load applied flatwise of the sheet.

20. The load shall be applied on the ends of the specimen and the crosshead speed of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. (1.27

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1931 Book of A.S.T.M. Tentative Standards, p. 220.

mm.) per minute when the machine is running idle. For the best results use the slowest possible speed.

Report. 21. The report shall include the following:

(*a*) The dimensions of each specimen in inches or millimeters;

(*b*) The direction of application of the load;

(*c*) The load on each specimen in pounds or kilograms at the first sign of failure;

(*d*) The ultimate compressive strength in pounds per square inch or kilograms per square millimeter, of each specimen, calculated from the area of each specimen measured before the load is applied;

(*e*) The general character of the material tested; with a description of how it acts under the applied load.

WATER ABSORPTION TESTS

Scope. 22. The water absorption tests are intended to determine the rate at which water is absorbed by the material when immersed, the total quantity absorbed at saturation, and the volatile content as received.

NOTE.—The electrical properties of different materials are not necessarily affected to the same extent by the same increase in moisture content so that the water absorption test must be correlated with the desired electrical tests.

The water immersion test and exposure to air of high humidity are not always directly comparable and should be considered before substituting one for the other.

(*A*) *Rate of Absorption*

Specimen. 23. The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches to the nearest 0.001 in. shall be measured on the original specimen at the center.

Procedure. 24. To determine the rate of absorption, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately re-weighed. The difference between the original weight and the dry weight shall be recorded as loss in weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water maintained at a temperature of 25° C. ± 2° C. (77° F. ± 3.6° F.)

throughout the test. At the end of 2 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. If the specimen is $\frac{1}{16}$ in. in thickness or less it shall be weighed in a weighing bottle. The difference between the weight of the wet specimen and that of the dry specimen shall be recorded as the weight of water absorbed in 2 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen.

(*c*) After 24 hours immersion the specimen shall again be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed. The difference between the weight of the specimen after 24 hours immersion and the weight of the dry specimen shall be recorded as the water absorbed in 24 hours. The percentage of water absorbed shall be calculated on the weight of the dry specimen. If the individual 24-hour absorptions differ by more than 10 per cent from the average absorption of the two specimens the test shall be repeated.

Report. 25. The report shall include the values for each of the two specimens and the average values as follows:

(*a*) The thickness of the specimen before the test, to the nearest 0.001 in.;

(*b*) The percentage loss in weight on drying calculated on the original weight;

(*c*) The percentage of water absorbed in 2 hours and in 24 hours calculated on the dry weight.

(*B*) *Total Absorption at Saturation*

Specimen. 26. (*a*) The test specimen shall be 3 by 1 in. by the thickness of the material. It shall be sawed or sheared from the sample so as to have smooth edges free from cracks. The cut edges of all test specimens shall be finished with No. 0 or finer sandpaper or emery cloth. Sawing and sandpapering operations should be slow enough so that the material is not heated appreciably. The thickness in inches measured to the nearest 0.001 in. shall be measured on the original specimen at the center and on the reduced specimen in case a reduced specimen is used (see Paragraph (*b*)).

(*b*) When the sample for determining total absorption is so thick that too long a time is required for saturation using the full thickness, the thickness may be reduced as follows: The sample shall be machined to a thickness of about $\frac{5}{64}$-in., both surfaces parallel to the laminations being machined off. This may readily be done with a smooth-cut circular saw. It shall then be sanded to $\frac{1}{16}$ in. in thickness, finishing with No. 0 or finer sandpaper. While the sanded surfaces of the sample should be approximately parallel with the laminations, the thickness may vary ±0.010 in., since the object is to provide comparable specimens which will reach saturation in a reasonable time. The machined and sanded sample shall then be cut into specimens 3 by 1 in. and the edges sanded.

Procedure.

27. To determine the total water absorption at saturation, two specimens shall be tested individually as follows:

(*a*) The specimen shall be weighed, dried in an oven for 1 hour at from 105 to 110° C., cooled in a desiccator and immediately reweighed. The difference between the original weight and the dry weight shall be recorded as loss of weight on drying. The percentage loss in weight shall be calculated on the original weight.

(*b*) The dried specimen shall then be immersed in distilled water at a temperature of from 20 to 30° C. At the end of 24 hours the specimen shall be removed from the water, the surface water wiped off with a dry cloth and the specimen weighed immediately and then replaced in the water. The weighings shall be repeated every day for the first week and every week thereafter until the increase in weight, as shown by three consecutive weighings, averages less than 1 per cent of the total increase in weight, when the specimen shall be considered to be saturated.

(*c*) The difference between the saturated weight and that of the dry weight shall be considered as the water absorbed at saturation. The percentage of water absorbed shall be calculated on the dry weight of the specimen.

Report.

28. This report shall include the values for each of the two specimens as follows:

(*a*) The original thickness of material, measured to the nearest 0.001 in.;

(*b*) If a reduced specimen is used, the thickness measured to the nearest 0.001 in.;

(*c*) The percentage loss in weight on drying, calculated on the original weight;

(*d*) The percentage of water absorbed at saturation, calculated on the dry weight.

(*C*) *Volatile Matter*

Specimen.

29. The test specimen shall conform to the requirements specified in Section 12.

Procedure.

30. To determine the volatile matter, two specimens shall be tested individually as follows:

The specimen shall be weighed, dried in an oven at from 105 to 110° C. until the decrease in weight as shown by two consecutive weighings at least 24 hours apart is less than 1 per cent of the total decrease in weight. The difference between the original weight and the dry weight shall be recorded as the volatile matter present in the specimen as received (this includes in addition to water any volatile solvent left during manufacture). The percentage of volatile matter shall be based on the weight of the dry specimen.

Report. 31. The report shall include the values for each of the two specimens as follows:

(*a*) The original thickness of the material measured to the nearest 0.001 in.;

(*b*) The percentage of volatile matter, based on the weight of the dry specimen.

DIELECTRIC STRENGTH

Dielectric Strength. 32. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (A.S.T.M. Designation: D 149 - 31 T) of the American Society for Testing Materials.[1]

PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT

Dielectric Constant. 33. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Power Factor and Dielectric Constant at Frequencies of 100 to 1500 Kilocycles (A.S.T.M. Designation: D 150 - 31 T) of the American Society for Testing Materials.[2]

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[1] See p. 867.

[2] See p. 877.

TENTATIVE METHOD OF TEST FOR COMPARING THE THERMAL CONDUCTIVITIES OF SOLID ELECTRICAL INSULATING MATERIALS[1]

A.S.T.M. Designation: D 325 - 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1930; Revised, 1931.

Scope. 1. This method is intended for comparing the thermal conductivities of solid electrical insulating materials which are in the form of flat sheets. An accuracy of 10 per cent can be obtained with this method.

Definition. 2. *Thermal Conductivity.*—The thermal conductivity of a homogeneous material is the rate of heat flow under steady conditions, per unit area, and per unit temperature gradient in the direction perpendicular to the area. Thermal conductivity is expressed in watts per square centimeter per degree centigrade per centimeter.

Principle. 3. The principle of the method is analogous to the potentiometer method of comparing electrical resistances. A specimen of unknown conductivity is placed in series with a standard specimen of known conductivity between plates which are maintained at different temperatures. When a steady state of heat flow is attained, the respective temperature differences across the standard and the test specimens are measured and the conductivity of the test specimen is calculated from the following relation:

$$K = K_1 \frac{L}{L_1} \times \frac{\Delta t_1}{\Delta t}$$

where K = the conductivity of the test specimen;
K_1 = the conductivity of the standard specimen;
L = the thickness of the test specimen;
L_1 = the thickness of the standard specimen;
Δt = the temperature difference of the test specimen;
Δt_1 = the temperature difference of the standard specimen.

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[1] **Criticisms of this Tentative Method are solicited and should be directed to Mr. J. A. Scott, Secretary of Committee D-9 on Electrical Insulating Materials, General Electric Co., Schenectady, N. Y.**

APPARATUS

Apparatus. 4. The apparatus, consisting of a heating plate, a cooling plate, three or four thermocouples, a calibrated galvanometer or a thermocouple potentiometer, an ice bath, and at least one standard specimen, shall conform to the following requirements:

(*a*) *Plates*—The heating and the cooling plates shall be flat pieces of metal. The contact surface of each plate shall have dimensions equal to or greater than the contact surface of the specimen. The metal surface which supplies or removes the heat from the specimens shall be maintained at a temperature which is constant and uniform within 0.1° C.

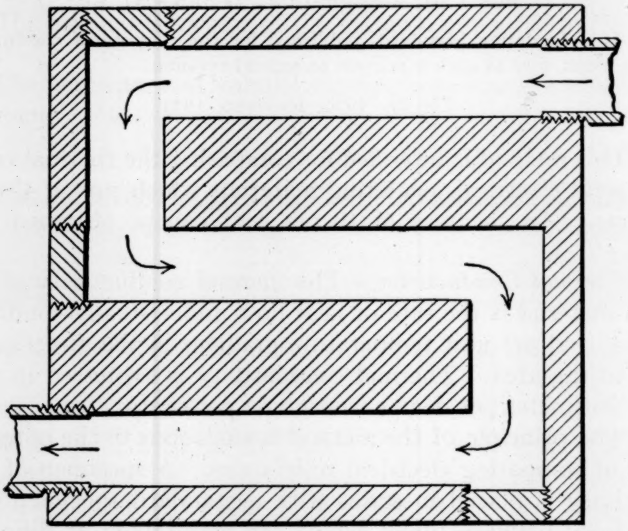

FIG. 1.—Cross-section of Heating or Cooling Plate.

NOTE.—The heating plate may be heated either electrically or by the vapor from a liquid boiling at a definite temperature. The cooling plate may be cooled by a liquid circulating through it. A platen from a steam-heated press makes a satisfactory heating or cooling plate. A plate of this description is shown in Fig. 1.

(*b*) *Thermocouples.*—Thermocouples shall be made from wire not larger than 0.25 mm. (0.010 in.) in diameter, or No. 30, A. w. g., one wire being of copper and the other of a suitable alloy which will give an electromotive force of about 40 microvolts per degree Centigrade. The wire shall be provided with suitable insulation of such thickness that the over-all diameter does not exceed 0.50 mm. (0.020 in.). The junctions shall be made by soldering or welding the wires. The measuring junctions of the thermocouples, used for determining the temperatures at the surface of the specimens shall be soldered to or embedded at, the midpoint of sheets of pure tin, or other malleable metal, which have the same shape as the contact surface of the specimens. Each sheet of tin shall not exceed 0.50 mm. (0.020 in.) in thickness, and shall be provided with a slot in which the wires leading to the junction may be laid. No part of the thermocouple or its mounting shall exceed 0.5 mm. (0.020 in.) in thickness. The reference or cold junction of each thermocouple shall be mounted in a glass tube not more than 2.5 mm. (0.1 in.) in diameter, which is sealed at its lower end and is immersed in a bath of crushed ice so that the junction is at least 100 mm. (4 in.) below the surface, and at least 25 mm. (1 in.) above the lower ice level.

NOTE.—The use of a separate reference or cold junction for each thermocouple is essential only when measurements are made on specimens of high graphite content or other materials which may be electrically conducting.

(*c*) *Galvanometer.*—If a galvanometer is used on the terminals of the thermocouples it shall have a sensitivity sufficient to indicate definitely a change of temperature of 0.1° C. at the hot junction of any of the thermocouples. The deflections of the galvonometer shall be sufficiently steady and the instrument shall be calibrated to warrant an accuracy of ±0.25° C.

(*d*) *Potentiometer.*—If a potentiometer is used on the terminals of the thermocouples it shall be sufficiently sensitive and precise to warrant an accuracy of ±0.25° C.

(*e*) *Ice Bath.*—The ice bath shall consist of a Dewar flask or other well-insulated vessel filled to a depth of at least 15 cm. (6 in.) with ice and water.

SPECIMENS

Test Specimens.

5. (*a*) Test specimens shall be in the form of flat sheets which may be square, circular, or rectangular in shape. The specimens shall not project beyond the edges of the heating or cooling plates and the total thickness of a test specimen and a standard specimen shall not exceed one-sixth of the edge of the square, the diameter of the circle or the shortest side of the rectangle.

(*b*) A convenient size for test specimens is approximately 20 cm. (8 in.) square and 1 cm. (0.4 in.) in thickness. Specimens should be uniform in thickness to within ± 1.5 per cent. Thickness measurements shall be made with an accuracy of 0.5 per cent at not less than ten points uniformly distributed over the surface. The average thickness shall be used for computing the thermal conductivity. When the material is soft or easily compressible, the measurement shall be made in such a way as to indicate the thickness under the pressure used in the test.

Standard Specimens.

6. (*a*) Standard specimens shall have the same shape and size as the test specimens. Any test in which the conductivity of the test specimen is found to be less than one-half or more than twice the conductivity of the standard specimen to which it was compared shall be tested again using another standard specimen having a conductivity nearer that of the specimen under test. Standard specimens may be made from materials the thermal conductivity of which is reasonably permanent and unaffected by changes in atmospheric humidity.

(*b*) Standard specimens shall be certified, by a standardizing laboratory, for thermal conductivity with an accuracy of ±2 per cent.

NOTE.—Standard specimens having considerable ranges of conductivities may be made from a rubber in which graphite is incorporated as a filler in varying amounts. Specimens have been made from a base compound of high rubber content and different proportions of 300-mesh pure graphite.

The composition of the base compound was as follows:

Plantation rubber, per cent	96.0
Zinc oxide, per cent	1.0
Stearic acid, per cent	0.75
Tetramethylthiuram disulfide, per cent	0.25
Sulfur, per cent	2.00
Total	100.00

The conductivities of the specimens were as follows:

GRAPHITE, PER CENT	THERMAL CONDUCTIVITY, WATTS, CM. $^{-1}$ (DEG. CENT) $^{-1}$
0	0.00143
15	0.00183
30	0.00248
45	0.00383
60	0.00824

PROCEDURE

Mounting of Plates and Specimens.

7. (*a*) The heating and the cooling plates and the specimens shall be placed in a horizontal position, one on top of the other. The order of assembly from the top down shall be as follows:

(1) Heating plate;
(2) Soft rubber sheet;
(3) Measuring junction of a thermocouple;
(4) Test specimen;
(5) Measuring junction of a thermocouple;
(6) Thin, soft rubber sheet;
(7) Measuring junction of a thermocouple;
(8) Standard specimen;

(9) Measuring junction of a thermocouple;
(10) Soft rubber sheet;
(11) Cooling plate.

(*b*) The pressure on the specimens shall be such that doubling the pressure does not change the apparent thermal conductivity by as much as 2 per cent.

(*c*) The assembled plates and test specimens shall be enclosed on all sides by at least 2 in. of good thermal insulating material in order to minimize the heat loss at the edges.

NOTE.—The soft rubber sheets called for in the above assembly are for the purpose of insuring good thermal contact at hard surfaces. Soft sheet rubber known as "dental dam" is a suitable and readily obtainable sheet for this purpose. One or more layers may be used at each surface to give the desired cushioning effect. When the specimens are soft and flexible these rubber sheets may be omitted, as may also one of the measuring junctions called for in Sections 5 and 7. Pressures of the order of 200 g. per sq. cm. (400 lb. per sq. ft.) are usually sufficient to insure good thermal contact of soft rubber specimens.

Procedure.

8. (*a*) *Temperature of the Plates.*—The heating and the cooling plates shall be maintained at temperatures which are constant within ±0.1° C. until the temperature differences across the specimens being compared are constant within ±0.25° C. for one hour, or ±0.10° C. for 30 minutes.

(*b*) *Temperature of Specimens.*—The mean of the temperatures at the two surfaces of the test specimen shall be considered the temperature of the specimen and shall be within ±10° C. of the temperature at which it is desired to know the thermal conductivity. Similarly, the mean of the temperatures at the two surfaces of the standard specimen shall be considered its temperature.

The temperature of the standard specimen shall be within ±10° C. of a temperature at which its thermal conductivity is known. The temperature difference across any specimen shall not be greater than 50° C. nor less than 10° C.

Calculations.

9. The thermal conductivity of the test specimen shall be calculated by the formula given in Section 3.

NOTE 1.—The thermal conductivity of most materials increases with increasing temperature. The temperature coefficient near room temperature is usually within the range of 0.002 and 0.005 per 1° C. The change of thermal conductivity with temperature is usually near enough to a linear relation to permit the mean temperature of a specimen to be used even when large temperature differences exist.

NOTE 2.—Temperatures in the specimens being compared may be made approximately those desired by the selection of appropriate temperatures for the heating and the cooling plates, and by the insertion of sheets of thermal insulating material in the test assembly. The total thickness of these accessory sheets and of the specimens being compared should not exceed the thickness specified in Section 5 as the total thickness of a test specimen and a standard specimen.

NOTE 3.—A temperature of 70° C. is recommended as the temperature at which the thermal conductivity of electrical insulating materials should be measured since many such materials are designed for use at 40° C. above room temperature.

REPORT

Report. 10. The report shall include the following:

(*a*) The standard specimen used;

(*b*) The thickness of the standard specimen;

(*c*) The thickness of the test specimen;

(*d*) The temperatures at the top and bottom of the test specimen;

(*e*) The temperatures at the top and bottom of the standard specimen;

(*f*) The computed conductivity of the test specimen and its mean temperature.

AMERICAN TENTATIVE STANDARD
A.S.A. NO.: L 3-1931

TENTATIVE SPECIFICATIONS
FOR
COTTON RUBBER-LINED FIRE HOSE FOR PUBLIC AND PRIVATE FIRE DEPARTMENT USE[1]

A.S.T.M. Designation: D 296 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; Revised 1931.[2]

These Specifications have been approved as
AMERICAN TENTATIVE STANDARD
by the American Standards Association

Scope.

1. These specifications cover $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, and $3\frac{1}{2}$-in. single, double or triple-jacketed cotton, rubber-lined fire hose suitable for use in public or private fire departments.

SPECIFICATIONS

MANUFACTURE

Cotton Fabric.

2. (*a*) The jackets shall be well, evenly and firmly made from good cotton, as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with good manufacturing practice.

(*b*) Each jacket shall be seamless and shall have the fillers woven around the hose throughout its length and the warps interwoven with and covering the fillers. The jackets may be separate or interwoven.

Rubber Lining.

3. (*a*) The lining shall be made of a properly vulcanized rubber compound which will comply with all the tests specified in Sections 6 to 14, inclusive. It shall consist of not less than three calendered sheets in one solid body and shall be lap-jointed with the lap as small and as neat as is consistent with good results.

(*b*) The lining shall be smooth and practically free from pitting and other imperfections and from corrugations.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] Revision approved by Committee E-10 on Standards, February 20, 1931.

(*c*) The lining shall be of uniform thickness and within the following limits of thickness exclusive of backing:

Internal Diameter of Hose, in.	Jackets	Lining Thickness Minimum, in.	Lining Thickness Maximum, in.
1½ and 2	Single and double	0.049	0.065
2½	Single, double and triple	0.058	0.072
3	Double and triple	0.058	0.072
3½	Double and triple	0.072	0.095

Backing. (*d*) *Backing.*—The backing, if used, shall not exceed 0.028-in. in thickness, as measured from the bottom of the corrugations. It need not be of the same composition as the rubber lining, but the adhesion between the rubber lining and the cotton jacket shall conform to the requirements specified in Section 14.

Flexibility. 4. The hose shall be flexible and easily coiled.

Workmanship. 5. The character of the workmanship shall be such as is incident to good manufacturing practice.

CHEMICAL PROPERTIES

Chemical Analysis. 6. The chemical tests required by the following chemical requirements shall be made in accordance with the methods of testing described in Sections 22 to 35, inclusive.

Chemical Composition. 7. The rubber lining shall on chemical analysis conform to the following requirements as to chemical composition; all percentages shall be calculated on the weight of the total compound.

	Minimum, per cent	Maximum, per cent
Organic Acetone Extract	..	4
Alcoholic-Potash Extract	..	1
Chloroform Extract	..	2.25
Ash (including carbon black)	50	57
Total Sulfur (excluding barytes)	..	3
Free Sulfur	0.5	..

PHYSICAL PROPERTIES

Methods of Testing. 8. The tests necessary to determine the physical properties which are specified in the following sections shall be made in accordance with the methods of testing described in Sections 36 to 51, inclusive.

Sampling. 9. A sample not less than 8 in. in length shall be taken from each lot of 1000 ft. or fraction thereof of hose for the tests specified in Sections 10 to 14, inclusive. All test specimens should be cut transversely from the sample, whenever possible.

10. (*a*) The tensile strength shall not be less than 1600 lb. per sq. in. when tested within 60 days of the date of final vulcanization. **Tensile Strength Within 60 Days.**

(*b*) *Elongation at Rupture.*—The elongation when rupture occurs in making the tensile strength test specified in Paragraph (*a*) shall be such that the original 2-in. gage length shall stretch to not less than 12 in.

11. (*a*) The tensile strength shall not be less than 1200 lb. per sq. in. when tested within one year of the date of final vulcanization. **Tensile Strength Within One Year.**

(*b*) *Elongation at Rupture.*—The elongation when rupture occurs in making the tensile strength test specified in Paragraph (*a*) shall be such that the original 2-in. gage length shall stretch to not less than 10 in.

12. (*a*) The permanent elongation or set, for tests made within 60 days, of samples cut transversely following a stretch from 2 to 10 in. shall not exceed 25 per cent and shall not exceed 30 per cent for samples cut longitudinally. **Permanent Elongation.**

(*b*) The permanent elongation or set, for tests made within 1 year, of samples cut transversely following a stretch from 2 to 8 in. shall not exceed 25 per cent and shall not exceed 30 per cent for samples cut longitudinally.

13. The adhesion between the lining and the cotton jackets shall be such that the rate of separation of a 1½-in. strip of lining from the jackets shall not be greater than 1 in: per minute under a weight of 12 lb. **Friction Test.**

14. After subjection to a dry heat of 158° F. (70° C.) ±2° F. (1.1° C.) for a period of four successive days of 24 hours each and then placed in air at room temperature for 24 hours, the tensile strength shall not be less than 900 lb. per sq. in. **Life Test.**

HYDROSTATIC TEST REQUIREMENTS

15. (*a*) Each length of single-jacketed hose shall be subjected to a hydrostatic pressure of 300 lb. per sq. in. for 5 seconds without leaking in the hose or at the couplings or breaking any threads in the jackets. Each length of double or triple-jacketed hose shall be subjected to a hydrostatic pressure of 400 lb. per sq. in. for 5 seconds without leaking in the hose or at the couplings, or breaking any threads in the jackets. **Hydrostatic Pressure Tests.**

(*b*) *Elongation.*—The elongation of the hose when tested as specified in Paragraph (*a*), shall not exceed 10 per cent of the length for single-jacketed hose, and 8 per cent for double or triple-jacketed hose measured from an initial pressure of 10 lb. per sq. in. **Elongation.**

Twist.

(*c*) *Twist.*—The hose, when tested as specified in Paragraph (*a*), shall not twist more than shown in the following table:

INTERNAL DIAMETER OF HOSE, IN.	JACKETS	TWIST, DEG. PER FT.
1½ and 2	Single	50
2½	Single	25
1½ and 2	Double	29
2½, 3 and 3½	Double and triple	12.5

The twist requirements refer to the final twist, in a direction to tighten, rather than loosen the couplings. No final twist in a direction tending to loosen the coupling shall be permitted.

Warp and Rise.

(*d*) *Warp and Rise.*—The hose, when tested as specified in Paragraph (*a*), shall not warp more than 20 in. from a straight line drawn from center to center of the couplings. Single-jacketed hose shall not rise from the level of the test table more than indicated in the following table, and no rise shall be permitted for double and triple-jacketed hose:

INTERNAL DIAMETER OF HOSE, IN.	JACKETS	PERMISSIBLE RISE, IN.
1½ and 2	Single	7
2½	Single	4

Bursting Strength Tests.

16. A 3-ft. sample in every lot of 3000 ft. or fraction thereof of hose, shall stand without failure, while lying either straight or curved to a radius of 27 in., a hydrostatic pressure as indicated in the following table:

INTERNAL DIAMETER OF HOSE, IN.	JACKETS	REQUIRED PRESSURE, LB. PER SQ. IN.
1½, 2 and 2½	Single	500
1½, 2 and 2½	Double and triple	600
3 and 3½	Double and triple	600

Kink Tests.

17. One full length in every lot of 500 ft. or fraction thereof of hose shall stand without failure, while kinked, a hydrostatic pressure as indicated in the following table:

INTERNAL DIAMETER OF HOSE, IN.	JACKETS	REQUIRED PRESSURE, LB. PER SQ. IN.
1½, 2 and 2½	Single	300
1½ and 2	Double	350
2½	Double and triple	350
3 and 3½	Double and triple	250

Place of Test.

18. All hydrostatic tests shall be performed either at the factory or at the destination, at the discretion of the purchaser. Arrangements for such tests shall be subject to arrangement reached between the manufacturer and purchaser, at the time the order is placed.

DIMENSIONS AND MARKING

19. The hose shall have an internal diameter as shown by a tapered plug gage of not less than $1\frac{1}{2}$, 2, 3, or $3\frac{1}{2}$ in., as ordered. In the case of $2\frac{1}{2}$-in. hose, the internal diameter as measured in this manner shall not be less than $2\frac{9}{16}$ in. **Diameter.**

20. The hose shall be furnished in nominal lengths of 50 ft. **Length.**

21. Beginning at a point not less than 4 ft. from each end, each 50-ft. length of hose shall be stenciled at two places in indelible letters at least 1 in. in height with the name of the manufacturer and the month and year of manufacture. **Marking.**

METHODS OF TESTING

CHEMICAL ANALYSIS[1]

REAGENTS

22. (*a*) *Acetone.*—The acetone shall be chemically pure and shall be freshly redistilled over anhydrous sodium carbonate, using the 56 to 57° C. fraction. **Reagents.**

(*b*) *Alcoholic-Potash Solution.*—The alcoholic-potash solution shall be of normal strength. It shall be made by dissolving the required amount of KOH in alcohol which has been purified as follows:

Dissolve 1.5 g. of $AgNO_3$ in 3 cc. of water and add it to 1000 cc. of alcohol. Dissolve 3 g. of KOH in the smallest amount of hot water, cool, add it to the alcoholic-silver nitrate solution, and shake thoroughly. Allow the solution to stand for at least 24 hours, filter, and distill. (Alcohol denatured with 10 per cent by volume of methanol may be used in place of ethyl alcohol.)

(*c*) *Nitric Acid - Bromine Solution.*—The nitric acid - bromine solution shall be prepared by adding a considerable excess of bromine to concentrated HNO_3 and shaking thoroughly.

(*d*) *Zinc - Nitric Acid Solution.*—The zinc - nitric acid solution is made by adding 200 g. of zinc oxide to 1000 cc. of concentrated HNO_3.

(*e*) *Barium Chloride Solution.*—Barium chloride solution shall be made by dissolving 100 g. of crystallized barium chloride in 1 liter of distilled water, and adding two to three drops of concentrated HCl. If there is any insoluble matter or cloudiness, the solution shall be heated overnight on the steam bath and filtered.

23. The purity of all materials shall be checked and determined by blank analyses. **Blank Analyses.**

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[1] These methods of chemical analysis are in accordance with the more complete procedure as given in the Tentative Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297 – 31 T) of the American Society for Testing Materials, see p. 947.

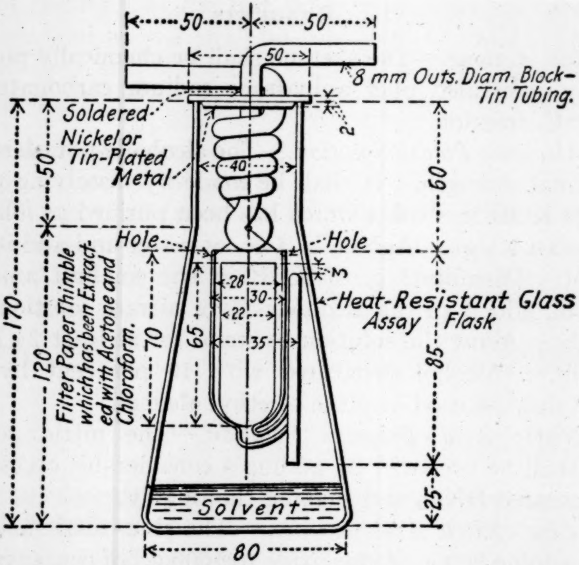
PREPARATION OF SAMPLE

Preparation of Sample. 24. Before preparing a sample for analysis the analyst shall by inspection, assure himself that it has not been contaminated. The sample shall be prepared by taking pieces from various parts of the original sample and separating them from foreign matter. The rubber shall be ground to the required fineness on a rubber mill or cut with scissors so as to pass a No. 14 sieve.

METHODS OF ANALYSES

Acetone Extract

Extraction Apparatus. 25. The extraction apparatus used here and for other extractions shall be of the type similar to that shown in Fig. 1. The flask shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between 2.5 and 3.5 minutes.


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
Soldered
Nickel or Tin-Plated Metal
2
40
50
60
Hole
Hole
3
28
30
22
35
Heat-Resistant Glass Assay Flask
170
120
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
70
65
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 1.—Extraction Apparatus.

Procedure. 26. Place 2 g. of rubber in a thimble made by folding a filter paper so that it will fit in the extraction cup, which is suspended in a weighed extraction flask. Extract the sample continuously for 16 hours, unless the solution in the thimble is still colored at the end of that time, when the extraction shall proceed for a further period of 4 hours or longer. Carefully note all characteristics of the acetone extract, both when hot and cold. Distill off the acetone on a steam bath, recovering the acetone if desirable, at as low a temperature as possible. Loss of extract by bumping can be avoided by means of a gentle current of air. Care must be taken to avoid allowing the flasks to stand on the steam bath after the solvent has been removed, because appreciable quantities of free sulfur may be lost by so doing. Dry the extraction flask and contents in an air bath for 1 hour at 70° C., cool, and weigh. Keep the sample for future determinations.

$$\text{Percentage of acetone extract} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

Chloroform Extract

Chloroform Extract.

27. The rubber sample (see Section 26) is suspended in a second weighed extraction flask and extracted for 4 hours with chloroform. Care should be taken that any small particles of rubber, which are often carried down into the extract, are filtered off. Evaporate off the solvent and dry to constant weight, usually 1 hour at 70° C., cool, and weigh. The color of the chloroform solution should be recorded. Reserve the rubber for extraction with alcoholic potash.

$$\text{Percentage of chloroform extract} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

Alcoholic-Potash Extract

Alcoholic-Potash Extract.

28. Dry the rubber from the chloroform extraction at about 70° C. to remove the chloroform, transfer to a 200-cc. Erlenmeyer flask, add 50 cc. of alcoholic-potash solution, and heat under a reflux condenser for 4 hours. Filter into a 250-cc. beaker, wash with two 25-cc. portions of boiling alcohol; then with three 25-cc. portions of boiling water, and evaporate the filtrate just to dryness. Use about 75-cc. of distilled water to transfer the residue to a separatory funnel. Acidify the solution with HCl (10-per-cent), testing with Congo-red paper. Extract with four 25-cc. portions of ether, unless the fourth portion should be colored, when the extraction must be continued until no further quantity can be removed. Unite the ether fractions and wash thoroughly with distilled water until free from acid (two washings are generally sufficient). Filter the ether solution through a plug of absorbent cotton into a weighed flask, wash with ether, evaporate, dry to constant weight at 70° C., cool, and weigh.

$$\text{Percentage of alcoholic-potash extract} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

Free Sulfur

Free Sulfur.

29. Add to the flask containing the acetone extract (Section 26), 60 cc. of distilled water and 2 to 3 cc. of bromine, and cover with a watch glass. Allow the flask to stand 30 minutes on the side of the steam bath, then heat cautiously over the direct steam bath until the solution is practically colorless, filter into a 250-cc. beaker, and dilute to about 175 cc. with distilled water. Precipitate with barium chloride and determine in the usual manner.

$$\text{Percentage of free sulfur} = \frac{\text{Wt. of } BaSO_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

Subtract the percentage of free sulfur thus determined from the acetone extract (Section 26) and call the result "organic acetone extract."

Total Sulfur

Total Sulfur Recommended Method.

30. (*a*) *Recommended Method.*—Place 0.5 g. of rubber in a porcelain crucible of about 75-cc. capacity, add 15 cc. of the nitric acid-bromine solution, cover the crucible with a watch glass, and let it stand for 1 hour in the cold. Heat for 1 hour on the steam bath, remove the cover, rinse it with a little distilled water, and evaporate to dryness. Add 3 cc. of HNO_3, cover, warm a short time on the steam bath, then let it cool. Carefully add in small portions, by means of a glass spatula, 5 g. of sodium carbonate (weighed to 0.5 g.). The watch glass is to be raised only high enough to permit the introduction of the spatula. The carbonate is allowed to slide down the side of the crucible and is not dropped directly into the acid. Rinse the watch glass with 2 or 3 cc. of hot distilled water and stir the mixture thoroughly with a glass rod. Digest for a few minutes, spread the mixture halfway up the side of the crucible to facilitate drying, and dry on a steam bath. Fuse the mixture by heating over a sulfur-free gasoline flame.

(*b*) Place the crucible in an inclined position on a wire triangle and start the ignition over a low flame. The tendency for the organic matter to burn too briskly is controlled by judicious use of the stirring rod with which the burning portion is scraped away from the rest. When part of the mass is burned white, a fresh portion is worked into it until all of the organic matter is destroyed. It is necessary to hold the edge of the crucible with tongs. Toward the last half of the operation the flame should be increased. It is unnecessary to heat the crucible to redness. With care, a crucible can be used for at least 10 to 12 fusions.

(*c*) After a fusion, allow the crucible to cool, place it in a 400-cc. beaker, add sufficient distilled water to cover the crucible (about 125 cc.), and digest on the steam bath for 2 hours, with occasional stirring. If the filtration can not be made on the same day, do not add the water, but allow the fusion to stand overnight.

(*d*) Filter the solution into a covered 400-cc. beaker containing 5 cc. of concentrated HCl, and wash the residue thoroughly with hot water. (A qualitative test of barium can be made on the residue.) Complete the acidification of the filtrate and washings and add 2 cc. of concentrated HCl in excess. Cover the beaker and heat the solution on the steam bath. The total volume of the solution should be 300 cc. The solution must be acid to Congo paper in order to insure the complete destruction of the carbonates. Precipitate with barium chloride and determine the sulfur in the usual manner.

$$\text{Percentage of total sulfur} = \frac{\text{Wt. of } BaSO_4 \times 9.1373}{\text{Wt. ot sample}} \times 100$$

Total Sulfur, Alternate Method.

31. (*a*) *Alternate Method.*—When this method is used the total sulfur determined represents the sulfur exclusive of that originally present as barytes or formed from barium salts, if present in the compound.

(*b*) Place a 0.5-g. sample in a 500-cc. Erlenmeyer destruction flask of Pyrex glass, quartz or similarly resistant material. Add 10 cc. of zinc oxide - nitric acid solution and moisten the sample thoroughly. If convenient, the mixture may be allowed to stand overnight. By so doing the sample becomes partly decomposed; this permits the addition of fuming HNO_3 with no danger of ignition of the sample. Add 15 cc. of fuming HNO_3 and whirl the flask rapidly to keep the sample immersed to avoid ignition by too rapid oxidation. With some samples it will be found necessary to cool the flask under a stream of tap water.

(*c*) When the solution of the rubber is complete, add 5 cc. of a saturated water solution of bromine and slowly evaporate the mixture to a foamy sirup.

(*d*) If particles of organic matter remain at the end of the evaporation, add a few cubic centimeters of fuming HNO_3 and re-evaporate as before. Cool, and add a few crystals of potassium chlorate to assist in the oxidation of the sulfur and the decomposition of any nitrates.

(*e*) Place the flask on asbestos gauze and evaporate the mixture to dryness over a Tirrill burner. Then bake the mixture at the highest temperature of the burner until all nitrates are decomposed and no more nitrogen peroxide fumes can be detected. When the baking is complete, cool the flask, add 50 cc. of HCl (1:6) and heat until solution is complete. (In case the original mixture contains barium sulfate or other salts, they will be precipitated at this point with consequent loss of sulfur in the case of the latter. If litharge is present in the mixture, lead salts, not otherwise removed, will be eliminated in the final washings with boiling water.) Filter the solution, dilute to 300 cc., precipitate with barium chloride, and determine the sulfur in the usual manner.

$$\text{Percentage of total sulfur} = \frac{\text{Wt. of BaSO}_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

Ash

Ash, Rapid Method.

32. *Rapid Method.*—Wrap a 1-g. sample in a filter paper, extract with acetone for 4 hours, and transfer to a weighed, approximately 50-cc. porcelain crucible. Ash the sample in a muffle furnace by heating at the following rate:

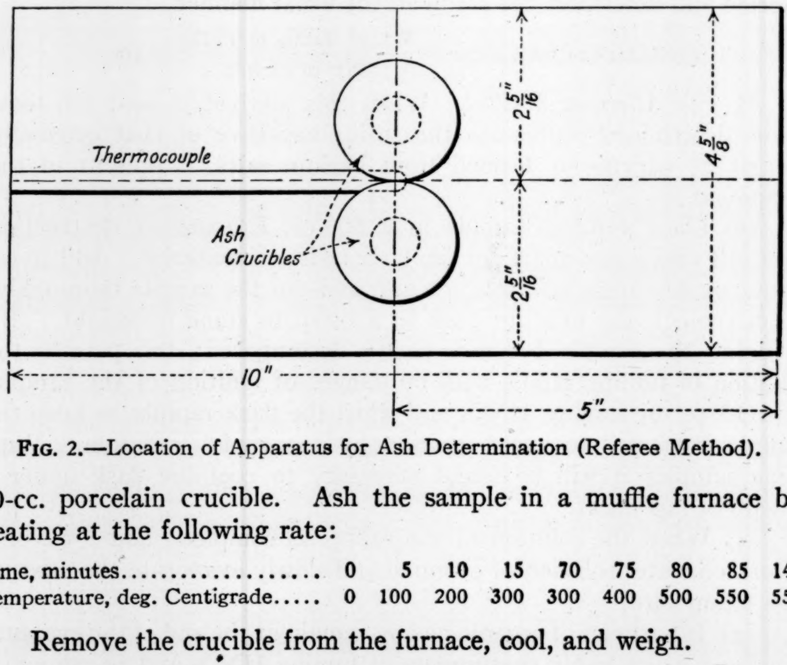


FIG. 2.—Location of Apparatus for Ash Determination (Referee Method).

Time, minutes	0	5	10	15	70	75	80	85	145
Temperature, deg. Centigrade	0	100	200	300	300	400	500	550	550

Remove the crucible from the furnace, cool, and weigh.

$$\text{Percentage of ash} = \frac{\text{Wt. of ash}}{\text{Wt. of sample}} \times 100$$

Ash, Referee Method.

33. (*a*) *Referee Method.*—In case of disagreement on results as obtained in the Rapid Method described in Section 32, an electric muffle furnace shall be employed for the test. Numbered porcelain crucibles 41 mm. in diameter and 25 mm. in height shall be used. The bottom of the furnace shall be covered by a sheet of asbestos 0.06 in. in thickness, cut to fit.

(*b*) Extract a 2-g. sample with acetone as described in the acetone extraction (see Section 26). Allow the extracted sample to dry at 100° C., cool in a desiccator and weigh. Divide the sample into two parts of equal weight; place each of them in crucibles previously ignited, cool in a desiccator, and weigh. Place the two crucibles, with contents, together (with their tops touching) in the furnace on a line crossing the furnace half-way between its ends, as shown in Fig. 2. Regulate the temperature of the furnace by means of a rheostat so that the temperature corresponds to the curve shown in Fig. 3, with a maximum permissible variation of ±25° C. Measure the temperature with a thermocouple (previously calibrated) enclosed in a quartz tube closed at one end, 6 to 7 mm. in diameter, 0.5 to 1 mm. in thickness, and placed in a horizontal position in contact with the asbestos sheet on the bottom of the furnace, so that the hot junction of the couple is on a line crossing the furnace half-way between its ends, and half-way between the two crucibles, as shown in Fig. 2. Adjust the door of the furnace to conform to the following requirements:

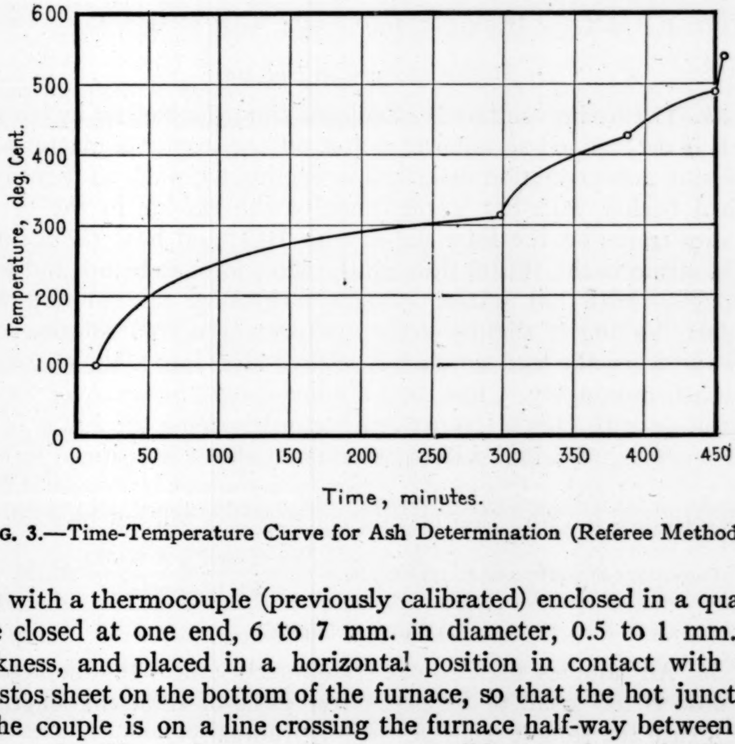


FIG. 3.—Time-Temperature Curve for Ash Determination (Referee Method).

	OPENING
First 400 minutes	½ in.
From 400 to 450 minutes	1½ in.
Balance of period (7 minutes)	wide open

(*c*) At the end of the period of heating, as shown, remove the crucibles from the furnace, cool in a desiccator and weigh.

$$\text{Percentage of ash} = \frac{\text{Wt. of ash}}{\text{Wt. of sample}} \times 100$$

Sulfur in Ash

Sulfur in Ash.

34. Add 3 cc. of nitric acid - bromine solution to the ash (see Section 32), cover with a watch glass and heat for 1 hour, remove the cover, rinse it with a little distilled water, and evaporate to dryness. Complete the determination of sulfur as described in Section 30 (*d*).

Save the insoluble residue, after filtering the solution of the fusion mixture in water, for testing in accordance with Section 35.

Sulfur as Barium Sulfate

Sulfur as Barium Sulfate.

35. The barium sulfate is calculated from the barium in the ash, which is determined as follows: Filter off the insoluble matter after the fusion and extraction described in Section 34, wash back into the original beaker with hot water, dissolve the residue in the beaker and any traces on the filter paper with HCl, and heat the solution on the steam bath. Filter through the same filter as before and wash thoroughly with hot water. Nearly neutralize the solution with NH_4OH, leaving it slightly acid. Saturate the cold solution with H_2S, and when the lead sulfide has settled, filter into a 400-cc. beaker and wash thoroughly. The total volume should be not over 200 cc. Precipitate with H_2SO_4 (10-per-cent) and determine the sulfur in the usual manner. Barium sulfate determined above is assumed to have been added as such. Obviously, if barium carbonate is present, it must be determined in order that an undue correction will not be made.

$$\text{Percentage of sulfur as barium sulfate} = \frac{\text{Wt. of } BaSO_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

PHYSICAL TESTS

Cutting of Samples.

36. All samples shall be cut transversely unless the diameter of the hose is too small to furnish a test piece of sufficient length, in which case the sample shall be cut longitudinally.

Temperature.

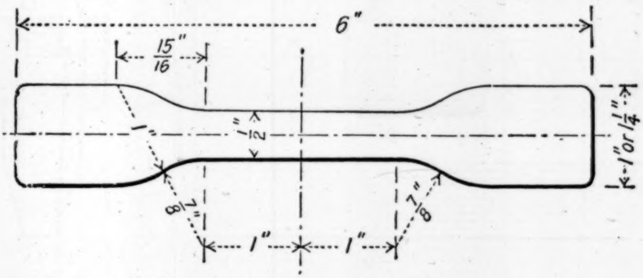
37. All tests of the rubber parts shall be made when possible in a room the temperature of which is not less than 60 nor more than 90° F. In case of a failure obtained when room temperatures are outside of these limits, rejection shall not be made until check tests are made within the specified temperature limits. No tests shall be made, if so desired by the manufacturer, until the article to be tested has been standing at least 48 hours after vulcanization.

Average Reading. 38. Acceptance or rejection shall be based on the average of at least four determinations for each item. In arriving at these averages no weight shall be given to tests which are obviously in error and do not represent true average conditions; for example, cases in which the tensile strength is low on account of a small flaw in the article or the friction is low on account of a small flaw in the friction compound.

(*A*) *Tensile Strength and Elongation at Rupture*

Apparatus. 39. An accurately calibrated testing machine so operated that the jaws separate at a uniform rate of 20 in. per minute, shall be employed in determining the tensile strength and elongation at rupture.

Test Specimen. 40. A section of hose 1 in. in width shall be cut in accordance with Section 36 and the rubber parts shall be carefully separated from the fabric, using benzine, if necessary. The benzine used in this case shall be about 76° Baumé, free from oil. No test shall be performed, if so desired by the manufacturer, until the specimen has been allowed to stand for 1 hour after it has in any way been in contact with benzine. From this 1-in. section of rubber a test specimen, as shown in Fig. 4, which shall be without physical injury shall be cut by a die, see Fig. 5. The specimen as thus prepared shall then be buffed free from corrugations.



(*a*) ½ by 2-in. Specimen.

Fig. 4.—Tensile Strength and Permanent Elongation Test Specimen

Marking. 41. Gage marks 2 in. apart shall be placed on the reduced section of the test specimen one on each side of the center and 1 in. therefrom. These marks shall be at right angles to the direction of pull of the test specimen in the machine. Great care shall be taken that the marks are not too wide and that at the time of marking, the test specimen shall have been lying for a sufficient length of time to be completely at rest. The marks shall be placed on the unbuffed side of the specimen.

Tensile Strength Tests. 42. (*a*) *Cross-Sectional Area.*—Before the tensile strength tests are made, the width of the test specimen between the gage marks shall be determined. After buffing off the backing or fabric impressions, the thickness shall be determined from the average of four readings, taken at equal points between the gage marks on the test piece by means of a spring-gage micrometer, provided with a $\frac{3}{8}$ in. foot applied under a pressure of 60 g. The cross-sectional area shall be calculated from these determinations.

(*b*) *Procedure.*—After clamping the test specimen in the jaws of the machine the movable jaw shall be so adjusted with the pointer reading zero on the scale that the test piece is just taut but not under tension. The operator shall throw on the current to start the screw and, when ready, throw in the engaging lever to start the jaws. He shall keep the elongation scale pointers opposite the outside edges of the gage marks on the test piece. The tensile strength shall be determined by stretching the test specimen in the testing machine until it breaks. If the test specimen breaks outside the gage marks or in the wider portions of the test specimen and the tensile strength

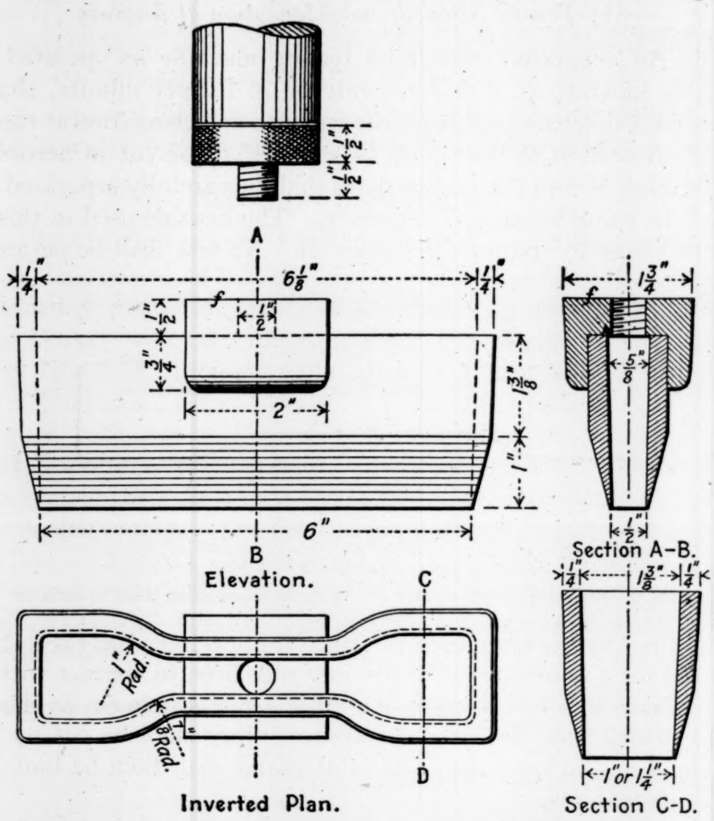


FIG. 5.—Die for ½ by 2-in. Specimens.

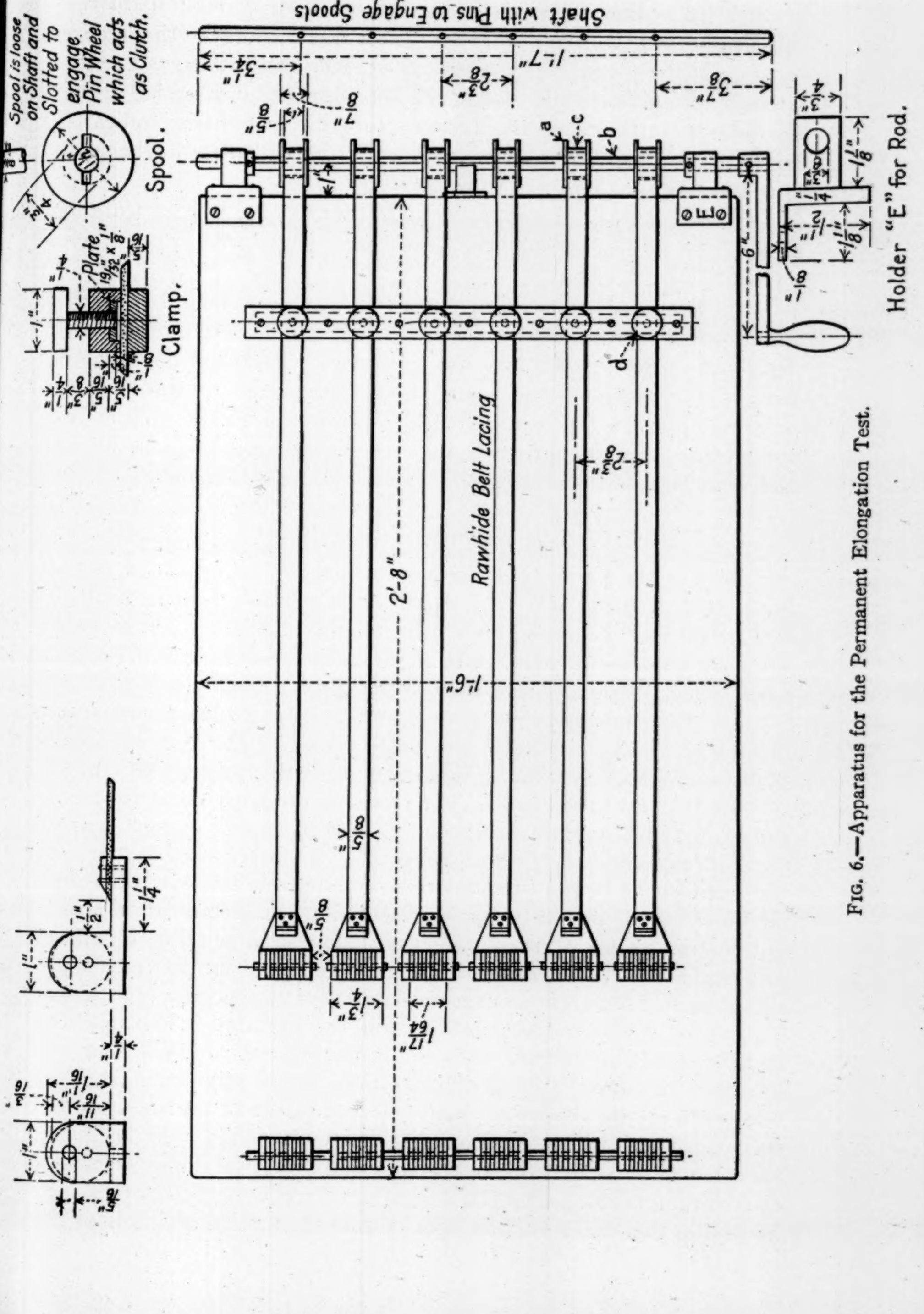

Shaft with Pins to Engage Spools
Spool is loose on Shaft and Slotted to engage Pin Wheel which acts as Clutch.
Spool.
Clamp.
Plate 19/32" x 1/8"
Rawhide Belt Lacing
Holder "E" for Rod.
E
a
b
c
d
1'-7"
3 1/4"
2 3/8"
3 7/8"
7/8"
5/8"
1/4"
2'-8"
1'-6"
6"
2 3/4"
5/8"
1 3/4"
1 17/64"
1"
1/2"
1 1/4"
1/4"
1 1/16"
11/16"
3/16"
5/16"
3/4"
1 1/8"
1 1/4"
1/8"

FIG. 6.—Apparatus for the Permanent Elongation Test.

is much below that called for in the specifications, it is probable that this specimen is faulty and that another would conform to the requirements. If the piece breaks outside the marks and yet shows a tensile strength above that called for in the specifications it is probable that the piece is faulty and its true tensile strength is higher than indicated. Since its recorded tensile strength exceeds that called for in the specifications it is not necessary to retest.

(*c*) *Calculation.*—From the actual breaking load as read from the scale of the testing machine the tensile strength in pounds per square inch shall be calculated.

Elongation at Rupture. 43. The elongation at rupture shall be determined at the same time and on the same specimen used for the tensile strength test described in Section 42. As the specimen is stretched between the jaws of the machine, the operator shall keep the elongation scale pointers opposite the outside edges of the gage marks on the test specimen. The elongation at rupture shall be measured in inches, and shall include the original 2 in. marked on the specimen.

(*B*) *Permanent Elongation*

Apparatus. 44. For the permanent elongation test, the apparatus shown in Fig. 6 shall be used. The spools, *a*, are free to slide on the shaft, *b*, and are slotted to engage pins, *c*, which act as clutches. The movable grips are attached to strips of leather-belt lacing $\frac{5}{8}$ in. in width which pass through clamps, *d*, and then to the spools, *a*.

Test Specimen. 45. The permanent elongation test shall be made only on specimens which have not been previously tested. The test specimens shall be prepared for testing in accordance with Sections 40 and 41.

Procedure. 46. Six test specimens shall be placed in the grips of the apparatus shown in Fig. 6, one of the spools, *a*, shall be moved along the shaft until it engages the corresponding pin, *c*. After placing the test specimen in the device previous to stretching, the test specimen shall be drawn just taut and the time measured at the instant of beginning of the stretching. All measurements of time shall be taken by means of a stop watch. The shaft shall be revolved until the desired elongation measured between the gage marks on the test specimen is obtained. The clamp, *d*, shall be tightened to hold the specimen in this position, and the spool shifted back so as to disengage the pin. When the test specimen has been held in this position for 10 minutes it shall be released and the time shall again be measured at the moment the specimen is released. This moment is simultaneously the beginning for a ten-minute period of rest. Immediately upon the expiration of the ten-minute rest period the elongation or recovery shall be measured by laying the test specimen upon a smooth surface which is of the temperature of the room and measuring to the outside of the gage marks with a scale graduated to 0.01 in. This operation shall be carried out on each of the test specimens in turn.

Calculation. 47. The difference between the final elongation and the original 2-in. gage length divided by the gage length and expressed as a percentage shall be taken as the permanent elongation.

(*C*) *Friction Test*

Test Specimen. 48. The test specimen shall be 2 in. in width and shall be cut transversely from the hose so as to give a rectangular sample the full circumference of the hose in length when cut through the walls and laid out flat. A strip of lining 1½ in. in width shall be cut out accurately, the cut extending through the lining but not entirely through the cotton jacket. This strip shall be started at one end to the extent of about 1½ in.

Procedure. 49. The free end of the cotton jacket shall be clamped in a stationary grip and the separated rubber lining shall be clamped in a freely suspended grip hanging vertically and to which the specified weight may be attached with suitable provision for supporting and releasing it slowly without jerking. The weight shall be released and the distance through which separation takes place shall be determined after a period of 10 minutes. The friction shall be taken as the rate obtained by dividing the total distances separated in inches (to the nearest 0.01 in.) by the elapsed time in minutes.

Referee Method. 50. (*a*) *Test Specimen.*—In case of disagreement as to the friction test described in Section 50, new test specimens 1½ in. in width shall be cut transversely from the hose so as to give a rectangular sample the full circumference of the hose in length when cut through the walls and laid out flat. One-quarter inch of the rubber lining shall be carefully and cleanly trimmed off on each side of the width for the entire length, without injuring the fabric, leaving a strip of rubber lining 1 in. in width undisturbed on a strip of cover 1½ in. in width. A separation between the lining and the cover of the strip shall be started for about 1½ in.

(*b*) *Procedure.*—The fabric of the test piece shall be fastened by means of a clamp to the power head of the testing machine used for the tensile strength tests, see Section 39. The rubber portion shall be clamped to the recording head without twisting. The machine shal be run at a uniform rate of 2 in. per minute. After separation commences the load shall be constantly watched to see that it does not fall below the specification requirement for a greater total length than 5 per cent of the total length separated. The load may be recorded on an automatic recording device. The entire friction layer shall be separated.

(*D*) *Life Test*

Life Test. 51. Test specimens for the life test shall be prepared in accordance with Sections 40 and 41. A hole about $\frac{1}{8}$ in. in diameter shall be punched near the end of an enlarged end so that the specimens may be suspended upon a small rod. Specimens so suspended shall be separated by washers at least $\frac{1}{4}$ in. in thickness to permit the free circulation of air between them. This rod with its strips shall be hung in a well-insulated electric oven within which the temperature can be maintained at 158° F. (70° C.) ± 2° F. (1° C.). These specimens shall be left in the oven at the specified temperature continuously for four days of 24 hours each. They shall then be removed, allowed to hang in the air at room temperature for 24 hours, after which the tensile strength shall be determined in accordance with Section 42.

HYDROSTATIC TESTS

Apparatus. 52. All hydrostatic tests shall be made with a pump equipped with calibrated gages.

Application of Pressure. 53. The increase in pressure shall be at the rate of not less than 300 lb. per sq. in. per minute. The hose under test shall be held under pressure for measurement not more than 2 minutes.

Elongation, Twist, Warp and Rise. 54. In the tests for elongation, twist, warp and rise the hose shall be stretched out for inspection, connected to the pump and filled with water, leaving the air cock open to allow all air in the hose to escape. The air-cock shall then be closed and a pressure of 10 lb. per sq. in. applied. All original measurements shall be taken at this pressure. After measurements are taken the test pressure shall be applied in accordance with Section 53 without releasing the pressure from the original pressure of 10 lb. per sq. in.

Bursting Strength Test. 55. Samples for the bursting-strength test shall be cut from lengths which have not been tested previously to more than 300 lb. per sq. in. for single-jacketed cotton hose and 400 lb. per sq. in. for multiple-jacketed hose.

(*b*) *Lying Straight.*—In the lying straight position the sample shall be allowed to rest on the surface of the test table with one end free and the test pressure shall be applied in accordance with Section 53.

(*c*) *Curved.*—In the curved position the sample shall be secured at both ends to a suitable test frame which is curved to a radius of 27 in. The test pressure shall be applied in accordance with Section 53.

Kink Test. 56. The test length in the kink test shall have a coupling tied back against the body of the hose so that there will be a sharp kink in the hose about 18 in. from the coupling. The test pressure shall be applied in accordance with Section 53.

TENTATIVE SPECIFICATIONS
FOR
STEAM HOSE[1]

A.S.T.M. Designation: D 54 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1921; REVISED, 1924, 1931.

Scope. 1. These specifications cover wrapped fabric steam hose suitable for steam connections when the steam pressure does not exceed 125 lb. per sq. in.

MANUFACTURE

Construction. 2. The hose shall consist of:

(*a*) An inner rubber tube;

(*b*) Cotton duck reinforcement;

(*c*) An outer rubber cover;

(*d*) A protective covering of wire armor when specified.

Rubber Tube. 3. The inner rubber tube shall be smooth, uniform in quality and thickness, and free from injurious defects.

TABLE I.—NUMBER OF PLIES.

INSIDE DIAMETER OF HOSE, IN.	NUMBER OF PLIES
$\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$	4
1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{5}{8}$	5
$1\frac{3}{4}$	6
2	8

Cotton Reinforcement. 4. (*a*) The reinforcement shall consist of plies of cotton duck cut on the bias and applied evenly and firmly over the tube with not less than a $\frac{1}{2}$-in. lap, not sewed. The number of plies shall be as specified in Table I. The plies of duck shall be well frictioned on both sides with a rubber compound which shall firmly join the plies to the rubber tube and cover and to each other.

(*b*) The cotton duck shall be evenly woven from high-grade cotton and shall be free from mechanical defects.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

These tentative specifications are in effect a revision of the former Standard Specifications for Steam Hose (A.S.T.M. Designation: D 54 - 20) which were accordingly discontinued in 1921.

(*c*) The reinforcements shall be sufficiently strong to enable the hose to successfully withstand the prescribed hydrostatic pressure test, yet at the same time be soft and pliable.

Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness, and free from injurious defects.

Wire Armor. 6. The wire for wire-wound hose shall be galvanized steel, half-round or elliptical, $\frac{7}{32}$ in. in diameter, wound tightly around the outside of the hose with a pitch of 1 in.

PHYSICAL PROPERTIES AND TESTS

Standard Methods. 7. The tests necessary to determine the physical properties which are prescribed in the following sections shall be made in accordance with the Standard Methods of Testing Rubber Products (A.S.T.M. Designation: D 15) of the American Society for Testing Materials.[1]

Test Samples. 8. (*a*) Two samples, each 24 in. in length, shall be taken from each lot of 500 ft. or less of each size of long-length hose and from each lot of 200 pieces or less of car-heating steam hose. One of these samples shall be used for hydrostatic tests and the other for the physical and steam tests.

(*b*) A portion of sufficient length shall be cut from one of the samples and subjected to tension, elongation and friction tests. The remaining portion of the sample shall be used for the steam tests.

Tests of Tube and Cover. 9. (*a*) In the case of hose 1 in. or less in diameter, the test specimens shall be cut longitudinally from the sample of hose; in the case of hose over 1 in. in diameter the test specimens shall be cut transversely.

(*b*) The tensile strength and elongation of the tube and cover shall not be less than the following values:

	BEFORE STEAM TEST	AFTER STEAM TEST
Tensile strength of tube, lb. per sq. in.	750	550
Tensile strength of cover, lb. per sq. in.	600	450
Elongation at rupture, per cent	200	100

Friction Tests. 10. The adhesion between plies, between the cover and the plies' and between the tube and the plies shall be such that the weights specified below will not cause a separation at a rate greater than 1 in. per minute:

	WEIGHT, LB.	
	BEFORE STEAM TEST	AFTER STEAM TEST
Between plies of duck	18	15
Between duck and tube	15	12
Between duck and cover	15	12

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

Maximum Deterioration after Steam Test.

11. After the steam test, the tensile strength and elongation of the tube and cover shall not be less than the values specified in Section 9 (*b*). Furthermore, after the steam test, the tensile strength and elongation of the tube and the cover shall not show an increase or decrease of more than 40 per cent of the original results.

Steam Test.

12. (*a*) The rack steam test shall be used. The test length described in Section 8 (*b*) shall be connected to a rack and dry saturated steam at an average pressure of 75 lb. per sq. in. ± 3 lb. shall be allowed to pass through the hose continuously for two periods of seven hours each. Between the first and second periods and between the second period and the time of testing, the hose shall be permitted to rest not less than 12 nor more than 18 hours.

(*b*) The hose upon examination immediately after its removal from the rack shall disclose no blistering of the tube nor loosening of the tube from the fabric. After steaming, the inside diameter of the hose shall not be more than 15 per cent greater than the original diameter for sizes having a nominal inside diameter under $\frac{3}{4}$ in. nor more than 13 per cent greater for sizes of $\frac{3}{4}$ in. and larger nominal inside diameters.

TABLE II.—HYDROSTATIC TEST PRESSURES.

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURES, LB. PER SQ. IN
$\frac{3}{8}$, $\frac{1}{2}$	800
$\frac{3}{4}$	750
1	750
$1\frac{1}{4}$	750
$1\frac{1}{2}$	650
$1\frac{5}{8}$	650
$1\frac{3}{4}$	650
2	550

Hydrostatic Tests.

13. The 24-in. section selected as described in Section 8 (*a*) shall be subjected to a hydrostatic test and shall not burst nor show leaks at a lower pressure than that specified in Table II for hose of its size.

SIZES AND DIMENSIONS

Sizes and Dimensions.

14. (*a*) The hose shall be in accordance with the size and length specified by the purchaser.

(*b*) The thickness of the cover shall not be less than 0.063 in. The thickness of the tube shall not be less than 0.125 in.

(*c*) The diameters of the hose shall be in accordance with Table III. The inside diameter shall not vary more than $\pm\frac{1}{32}$ in. and the outside diameter not more than $\pm\frac{1}{16}$ in. from the values given.

MARKING

Marking. 15. (*a*) Each 50-ft. length of hose shall have inlaid in rubber in three places, namely, midway between the ends and within 10 ft. of each end, a brand showing the name of the manufacturer, the month and year of manufacture, the trade name of the hose, and the legend "A.S.T.M. Specifications." In addition, each brand shall bear a serial number for each lot of 500 ft. or less of each size of long-length hose and for each lot of 200 pieces or less of car-heating steam hose, the serial number to begin with 1 on the first of each year and continue consecutively until the end of the year. Lengths shorter than 50 ft. shall have only one brand similar to the above at a point near the center of the length. The letters and figures shall be at least $\frac{1}{4}$ in. high, shall stand $\frac{1}{32}$ in. in relief, and shall be clear and distinct.

(*b*) Serial numbers of rejected hose shall not be applied to any other hose during the same calendar year.

TABLE III.—DIAMETERS.

NOMINAL INSIDE DIAMETER, IN.	NOMINAL OUTSIDE DIAMETER, IN.
$\frac{3}{8}$	1
$\frac{1}{2}$	$1\frac{1}{8}$
$\frac{3}{4}$	$1\frac{1}{2}$
1	$1\frac{13}{16}$
$1\frac{1}{4}$	$2\frac{1}{16}$
$1\frac{1}{2}$	$2\frac{5}{16}$
$1\frac{5}{8}$	$2\frac{7}{16}$
$1\frac{3}{4}$	$2\frac{5}{8}$
2	$3\frac{1}{16}$

INSPECTION AND REJECTION

Inspection. 16. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. But such tests shall be made within 60 days after receipt of the shipment and at the expense of the purchaser.

Rejection. 17. (*a*) Each length of hose which fails to meet any of the requirements of these specifications shall be rejected.

(*b*) Any material which fails in one or more of the tests specified in Sections 9 to 13, inclusive, may be resampled and retested at the expense of the manufacturer. For this purpose, two additional samples shall be selected from the hose for the test which failed to meet the requirements. Failure of either of the retested samples shall be cause for final rejection.

Rehearing.

18. Samples of rejected hose shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: 30-PER-CENT HEVEA RUBBER[1]

A.S.T.M. Designation: D 27 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1916; REVISED, 1921, 1928, 1931.

Scope. 1. These specifications cover conductors, rubber insulation, cable tape, cotton braid and lead sheaths. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser.

(*A*) CONDUCTOR

MANUFACTURE

Material. 2. The conductor shall be of soft annealed copper, properly tinned, and have the properties and characteristics herein required.

Strand 3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand.

Shape. 4. Each solid conductor and each strand shall be round and reasonably free from imperfections.

Stranding. 5. The stranding shall conform to the requirements of Table I and shall be either standard concentric or flexible as specified in the order.

Density. 6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of copper shall be taken as 8.89 g. per cu. cm. (See Appendix.)

PERMISSIBLE VARIATIONS IN DIMENSIONS

Diameter and Area. 7. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the specified value shall not exceed 1 per cent under or 2 per cent over for wire 0.02 in. in diameter and larger, and 0.1 mil under for wire less than 0.02 in. in diameter.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron Ohio.

NOTE.—These limits differ from those in the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials[1] because of the additional manipulation to which the wire is subjected subsequent to the stage where Specifications B 33 apply.

When the area of cross-section of cables is specified, the permissible variation shall not exceed 1 per cent under the specified value.

(*b*) *Method of Gaging Diameter.*—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

TABLE I.—STRANDING OF INSULATED CONDUCTORS.

For intermediate sizes use stranding for next larger size.

Conductors of No. 0000 and smaller are often made solid and this table of stranding should not be interpreted as excluding such practice.

In assembly column, "37 by 19 rope lay," signifies 37 strands of 19 wires assembled like a rope.

Size of Conductors	Standard Concentric Stranding,[a] Number of Wires	Flexible Stranding	
		Number of Wires	Assembly
2 000 000 cir. mils	127	703	37 by 19 rope lay
1 500 000 cir. mils	91	703	37 by 19 rope lay
1 000 000 cir. mils	61	427	61 by 7 rope lay
500 000 cir. mils	37	427	61 by 7 rope lay
300 000 cir. mils	37	259	37 by 7 rope lay
0 000 A. w. g	19	133	19 by 7 rope lay
1 A. w. g	19	91	Concentric
2 A. w. g	7	91	Concentric
4 A. w. g	7	61	Concentric
10 A. w. g	7	37	Concentric
16 A. w. g	7	26	Bunched
18 A. w. g	7	16	Bunched
20 A. w. g	7	10	Bunched

[a] The standard concentric stranding in this table agrees with Table XII of *Circular No. 31*, "Copper Wire and Cables," U. S. Bureau of Standards; and also Table II of Standard No. 30 "Wires and Cables" of the American Institute of Electrical Engineers.

(*c*) *Calculation of Area.*—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Paragraph (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection.*—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with Paragraph (*b*), or the area calculated in accordance with Paragraph (*c*), is not within the limits specified in Paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice the limits of Paragraph (*a*).

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 633.

PHYSICAL PROPERTIES AND TESTS

Tensile Properties.

8. (*a*) Each solid conductor and each strand previous to stranding shall be so drawn and annealed that after tinning it shall conform to the values in Table II.

After stranding, the tensile strength of each strand shall not exceed that specified in Table II by more than 5 per cent and the minimum elongation in 10 in. shall not be less than that specified in Table II by more than 5 per cent.

(*b*) For nominal diameters between listed sizes the requirements shall be those of the next larger sizes indicated in Table II.

Tension Tests.

9. (*a*) *Method of Test.*—Tension tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

TABLE II.—TENSILE REQUIREMENTS OF CONDUCTORS.

Size of Conductor		Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent
Diameter, in.	A.w.g. Number		
0.460 to 0.290	0000 to 1	36 000	30
0.289 to 0.103	2 to 10	37 000	25
0.102 to 0.021	12 to 24	38 500	20
0.020 to 0.012	25 to 28	39 000	15
0.011 to 0.003	29 to 40	40 000	10

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity.

10. The conductivity of the conductors after tinning shall be not less than that specified in Table III.

TABLE III.—CONDUCTIVITY REQUIREMENTS.

DIAMETER, IN.	A.W.G. NUMBER	CONDUCTIVITY, PER CENT
0.460 to 0.290	0000 to 1	97.65
0.289 to 0.103	2 to 10	97.15
0.102 to 0.021	12 to 24	96.15
0.020 to 0.012	25 to 28	94.15
0.011 to 0.003	29 to 40	93.15

NOTE.—The above values for conductivity conform to the International Annealed Copper Standard. (See Appendix.)

Tinning Test.

11. (*a*) The continuity of the tin coating of each sample before stranding or insulating shall be determined by the sodium polysulfide test which shall be made in accordance with the requirements of Sections 4 to 10, inclusive, of the Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (A.S.T.M. Designation: B 33) of the American Society for Testing Materials.[1]

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 25.

(*c*) *Retests and Rejections.*—If the specimens tested in accordance with Paragraph (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than 10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

(*B*) INSULATION[2]

Workmanship.

12. (*a*) The insulation shall be of either Class A or Class AO rubber compound as specified in the order. Where neither class is specified, the manufacturer may supply either class.

(*b*) The insulation shall consist of a properly vulcanized rubber compound which shall be homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto. Where the insulation is applied in more than one layer, adjacent layers shall be vulcanized into a homogeneous mass.

(*c*) Tape used over insulation during vulcanization will be accepted as tape under these specifications provided it conforms to the requirements of Sections 46 to 49, inclusive.

(*d*) Where repairs or joints are made in the insulation, the work shall be done in such manner that the repaired part of the joint, and all parts affected in the process, shall be as strong and durable electrically and mechanically as the remainder of the insulation and shall not exceed the limitations on the thickness specified in Section 18.

MANUFACTURE

Composition.

13. (*a*) The insulation shall consist of either Class A or Class AO rubber compound.

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[1] 1930 Book of A.S.T.M. Standards, Part I, p. 633.

[2] The requirements for Class A rubber compound in Part (*B*), Insulation, Sections 12 to 45, inclusive, of these specifications conform in substance but not in form with the Specifications for 30-per-cent Rubber Insulation for Wire and Cable for General Purposes (A.S.A. No.: C 8*d* 1 - 1928), approved as American Tentative Standard by the American Standards Association.

Class A rubber compound shall contain exclusively not less than 30 per cent nor more than 33 per cent of the best quality Hevea rubber which has not previously been used in a rubber compound, solid waxy hydrocarbons, suitable mineral matter and sufficient sulfur to properly vulcanize the compound.

Class AO rubber compound shall contain the same ingredients as Class A with the addition of antioxidants and organic accelerators.

(*b*) The mineral matter shall be dry and Class A insulation shall be free from organic materials.

(*c*) The waxy hydrocarbons used shall be solid at 54° C. and shall be free from saponifiable matter.

(*d*) Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to these specifications.

CHEMICAL PROPERTIES

Quantitative Requirements.

14. The insulation after vulcanization shall conform on analysis to the following requirements expressed as percentages by weight of the whole sample:

CLASS A AND CLASS AO	MAXIMUM	MINIMUM
Rubber, per cent	33	30
Waxy hydrocarbons, per cent	4	..
Free sulfur, per cent	0.7	..

	30-PER-CENT RUBBER[a]		33-PER-CENT RUBBER[a]	
	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
Saponifiable acetone extract, per cent:				
Class A	1.35	0.55	1.50	0.60
Class AO	2.00	....	2.20	....
Unsaponifiable resins, per cent:				
Class A	0.45	....	0.50	....
Class AO	1.00	....	1.10	....
Chloroform extract, per cent:				
Classes A and AO	0.90	....	1.00	....
Alcoholic potash extract, per cent:				
Classes A and AO	0.55	....	0.60	....
Total sulfur, per cent:				
Classes A and AO	2.10	....	2.30	....

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[a] For percentages between 30 and 33, the limits shall be in proportion to the percentage of rubber found.

Qualitative Requirements.

15. (*a*) The acetone solution from either compound shall not fluoresce and the acetone extract (60 ml.) from Class A compound shall not be darker than a light straw color.

(*b*) The hydrocarbons shall be solid, waxy and not darker than a light brown.

(*c*) The chloroform extract (60 ml.) shall not be darker than a straw color.

PHYSICAL PROPERTIES

Physical Properties.

16. The insulation shall conform to the following requirements as to physical properties:

	MAXIMUM	MINIMUM
Tensile Strength, lb. per sq. in.:		
Class A	..	1000
Class AO	..	1200
CLASS A AND CLASS AO		
Set in 2 in. gage length, in.	$\frac{3}{8}$	....
Elongation at rupture in 2-in. gage length, per cent	..	350
Specific gravity, 30-per-cent rubber	..	1.75[a]
Specific gravity, 33-per-cent rubber	..	1.67[a]

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[a] For percentage between 30 and 33, the specific gravity limit shall be in proportion to the percentage of rubber found.

Aging Tests.

17. Class AO rubber compound shall be subjected to the following tests:

(*a*) When subjected to the accelerated aging test, known as the Geer test, for 96 hours at 70° C., the rubber insulation shall show a depreciation of not more than 15 per cent in elongation or tensile strength.

(*b*) When subjected to the accelerated aging test, known as the "oxygen bomb test," for 96 hours at 300-lb. pressure and 70° C., the rubber insulation shall show a depreciation of not more than 25 per cent in elongation or tensile strength.

(*c*) Samples submitted for aging tests shall have no protective covering and shall be prepared as described in Section 26 (*a*). They shall be suspended vertically and free from contact with metal during the test. Depreciation due to aging shall be determined by testing the aged and unaged samples at the same time and within 24 hours after the completion of the aging tests.

THICKNESS

Thickness.

18. The average thickness of the insulation shall be not less than that given in Table IV. The thickness of the insulation at the thinnest part shall be not more than 10 per cent less than the specified thickness, but in no case shall such 10 per cent allowance exceed 0.0312 in.

ELECTRICAL PROPERTIES

High Voltage Test.

19. Each coil, reel, or length of wire or cable, after vulcanization and before the application of any covering other than tape or braid used in vulcanization shall successfully withstand the application of an alternating voltage of not less than that given in Table V for a period of 5 minutes.

Insulation Resistance. 20. Each coil, reel, or length of wire or cable after being subjected to the high voltage test specified in Section 19 shall have an insulation resistance not less than that given in Table VI.

METHODS OF TESTING

CHEMICAL ANALYSIS

Sampling. 21. Samples of the vulcanized rubber compound for chemical analysis shall be taken after the successful completion of the physical and electrical tests, and before applying impregnating compounds which may contaminate the rubber. The samples shall be taken at the option of the purchaser. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

TABLE IV.—THICKNESS OF INSULATION.

Thickness in sixty-fourths of an inch

Size of Conductor		Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
A. w. g. Numbers or Circular Mils	sq. mm.	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10000	11000
No. 14 to No. 9	2.08 to 6.63	3	4	6	8	10	12	14	16	18	20	22	24
No. 8 to No. 2	8.37 to 33.6	4	5	7	9	10	12	14	16	18	20	22	24
No. 1 to No. 0000	42.4 to 107	5	6	8	10	10	12	14	16	18	20	22	24
250 000 to 500 000 cir. mils	127 to 253	6	8	9	10	11	12	14	16	18	20	22	24
550 000 to 1 000 000 cir. mils	279 to 507	7	9	10	10	12	12	14	16	18	20	22	24
1 250 000 to 2 000 000 cir. mils	633 to 1013	8	10	10	10	12	14	16	18	18	20	22	24

NOTE.—The thickness of insulation (on each conductor in the case of multiple conductor cables) shall be based on the highest r. m. s. voltage between the conductor and the outside of its insulation.

For an intermediate size, the thickness shall be that of the next larger size.

TABLE V.—ALTERNATING TEST VOLTAGE IN KILOVOLTS.

Size of Conductor, A. w. g. Numbers or Circular Mils	Working Pressure, Volts, Direct or Alternating Commercial Power Frequencies											
	600 or less	750	1500	2500	3500	5000	6000	7000	8000	9000	10 000	11 000
No. 14 to No. 9	3	4	6	8	10	13	16	17	18	20	22	24
No. 8 to No. 6	3.5	5	7	9	10	13	16	17	18	20	22	24
No. 5 to No. 2	3.5	5	7	9	10	13	16	19	22	25	28	31
No. 1 to No. 0000	3.5	6	8	10	10	13	16	19	22	25	28	31
250 000 to 500 000 cir. mils	4	8	9	10	11.5	13	16	19	22	25	28	31
550 000 to 1 000 000 cir. mils	4	9	10	10	13	13	16	19	22	25	28	31
250 000 to 2 000 000 cir. mils	4	10	10	10	13	16	19	22	22	25	28	31

NOTE.—For an intermediate size or an intermediate working voltage, the test voltage shall be that of the next larger size, or working voltage listed.

Procedure. 22. The insulation shall be analyzed in accordance with (*B*) Complete Procedure as described in the Tentative Methods of

Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297 – 31 T) of the American Society for Testing Materials.[1]

TABLE VI.—INSULATION RESISTANCE, MEGOHMS-1000 FT. AT 60° F. (15.5° C.).[a]

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch							
	2	3	4	5	6	7	8	10
No. 18	8400	10 800	12 900	14 800	15 800	16 900	18 000	19 800
No. 16	7400	9 500	11 400	12 700	14 000	15 000	16 100	18 000
No. 14	....	8 100	9 800	11 400	12 400	13 500	14 000	16 100
No. 12	....	7 100	8 400	9 800	10 800	11 900	12 700	14 500
No. 10	....	6 050	7 150	8 400	9 500	10 600	11 400	12 700
No. 8	....	4 500	5 550	5 600	7 650	8 700	9 200	10 800
No. 6	....	....	4 500	5 550	6 350	7 150	7 650	9 200
No. 4	....	....	3 950	4 500	5 300	6 050	6 600	7 650
No. 2	....	....	3 450	3 950	4 500	5 000	5 550	6 600
No. 1	....	....	3 150	3 450	3 950	4 500	5 300	6 050
No. 0	....	....	....	3 150	3 700	4 200	5 000	5 550
No 00	....	....	....	2 900	3 450	3 950	4 500	5 000
No. 000	....	....	....	2 650	3 150	3 450	3 950	4 500
No. 0000	....	....	....	2 400	2 900	3 150	3 450	4 200
250 000 cir. mils	....	....	....	2 100	2 500	3 050	3 300	3 850
350 000 cir. mils	....	....	....	1 850	2 250	2 500	2 750	3 550
500 000 cir. mils	....	....	....	1 600	2 000	2 100	2 500	3 050
750 000 cir. mils	....	....	....	....	....	1 700	2 100	2 500
1 000 000 cir. mils	....	....	....	....	....	1 600	1 700	2 100
1 250 000 cir. mils	....	....	....	....	....	....	1 700	2 000
1 500 000 cir. mils	....	....	....	....	....	....	1 600	1 700
1 750 000 cir. mils	....	....	....	....	....	....	1 450	1 600
2 000 000 cir. mils	....	....	....	....	....	....	1 050	1 450

Size of Conductor, A. w. g. Numbers or Circular Mils	Thickness of Insulation in Sixty-fourths of an Inch						
	12	14	16	18	20	22	24
No. 18	21 400	22 700	23 800	24 800	25 900	26 400	27 200
No. 16	19 300	20 900	21 900	23 000	23 800	24 600	25 300
No. 14	17 700	18 700	20 100	20 900	21 600	22 700	23 200
No. 12	15 800	17 200	18 000	19 000	19 800	20 600	21 400
No. 10	14 000	15 300	16 400	17 200	18 000	18 700	19 500
No. 8	11 600	12 700	13 700	14 500	15 300	16 100	16 600
No. 6	10 300	11 100	12 100	12 900	13 500	14 300	14 800
No. 4	8 700	9 800	10 600	11 400	11 900	12 700	13 200
No. 2	7 650	8 400	9 000	9 800	10 300	11 100	11 600
No. 1	7 150	7 650	8 400	9 200	9 800	10 300	10 800
No. 0	6 350	7 150	7 900	8 400	9 000	9 500	10 000
No. 00	5 550	6 600	7 150	7 900	8 400	9 000	9 500
No. 000	5 300	6 050	6 600	7 150	7 650	8 200	....
No. 0000	5 000	5 550	6 050	6 600	7 150	7 650	....
250 000 cir. mils	4 600	5 300	5 800	6 350	6 750	....	....
350 000 cir. mils	4 100	4 500	5 000	5 550	5 950	....	....
500 000 cir. mils	3 550	3 950	4 500	4 750	....	....	....
750 000 cir. mils	2 750	3 300	3 700	4 100	....	....	....
1 000 000 cir. mils	2 500	2 900	3 300	....	....	....	....
1 250 000 cir. mils	2 250	2 650	3 050	....	....	....	....
1 500 000 cir. mils	2 100	2 500	....	....	....	....	....
1 750 000 cir. mils	2 000	2 400	....	....	....	....	....
2 000 000 cir. mils	1 700	2 250	....	....	....	....	....

[a] This table is based on a constant, $K = 21\,120$ in the following formula:

$$R = K \log_{10} \frac{D}{d};$$ where R = resistance in megohms-1000 ft., K = constant,

D = diameter over insulation, on each conductor, and d = diameter over conductor.

NOTE.—For an intermediate size, the insulation resistance shall be that of the next larger size.

Rejection and Retests.

23. The purchaser may make a chemical analysis on any one of the samples selected as described in Section 21 to determine if the

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[1] See p. 947.

compound conforms to the requirements of Sections 14 and 15. Failure of any sample selected to conform to the requirements shall be sufficient cause for rejecting the wire which that sample represents, except in the case of failure to conform to the requirements for either or both free sulfur and chloroform extract. In case of such failure, the coil from which the sample was taken shall be rejected and two additional samples shall be selected from the remainder of the order. The remainder of the order shall be accepted if both samples so selected conform to the requirements for free sulfur or chloroform extract. The entire order shall be rejected if either sample fails.

SPECIFIC GRAVITY

Specific Gravity.

24. The specific gravity shall be determined in accordance with Section 27 of the Tentative Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297 - 31 T) of the American Society for Testing Materials.[1]

TENSILE STRENGTH, SET AND ELONGATION AT RUPTURE

Sampling for Tests.

25. (*a*) When an order calls for less than 500 ft., physical tests may be waived at the option of the purchaser.

(*b*) When an order calls for 500 ft. or more, samples for purposes of test shall be taken from 10 per cent of the coils, reels or lengths, but in any case at least one sample shall be taken.

Test Specimen.

26. (*a*) *Size.*—The test specimen may be the entire section of the insulation in the case of small wires, or, in the case of a large wire or cable, either a segment of a section cut with a sharp knife held tangentially to the conductor or a shaped specimen cut out with a standard die. The test specimen shall be as free as possible from surface incisions and imperfections. There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the testing machine.

NOTE.—The removal of the rubber insulation can be greatly accelerated and in most cases a test specimen which is an entire section can be obtained free from surface incisions and imperfections by means of metallic mercury. The mercury should be introduced at one end of the sample between the insulation and the tinned surface of the conductor, and the sample inclined on a support with the end to which the mercury is applied at the top. The separation of the rubber insulation results from the amalgamation of the tin of the conductor with the mercury. The amalgamation is assisted by first immersing and rubbing the tinning on the exposed end of the conductor in the mercury.

(*b*) *Condition and Age.*—Specimens shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed in these specifications. Tests shall be made not earlier than 24 hours nor later than 60 days after the vulcanization unless approved by the manufacturer.

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[1] See p. 955.

(*c*) *Buffing.*—In the event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

Calculation of Area.

27. Calculation of the area of the test specimens shall be made as follows:

(*a*) Where the total cross-section of the insulation is used, the area shall be taken as the difference between the area of the circle whose diameter is the minimum average outside diameter of the insulation and the area of the conductor. The area of a stranded conductor shall be figured from its maximum diameter.

(*b*) Where a slice cut from the insulation by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values may be obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(*c*) Where the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of the specimen having a uniform cross-section.

(*d*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thin, the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(*e*) Where a portion of a sector of a circle has to be taken where the conductor is large and the insulation thick, the area shall be calculated as the proportional part of the area of the total cross-section.

Temperature at Test.

28. Physical tests shall be made at a room temperature not less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.) and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the test.

Testing Machine.

29. The testing machine shall be power-driven and preferably of the pendulum type. The machine shall be accurate within 1 per cent of the breaking load. A spring balance type of apparatus may be

used if provided with a device which will indicate the actual maximum load at which rupture takes place and if provision is made to prevent recoil of the spring.

Tensile Strength Test Procedure.

30. The tensile strength test shall be made on a specimen which has not been previously stretched. The specimen shall have a length of not less than 6 in., and shall be marked with gage marks 2 in. apart and placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. The specimen shall be stretched at the rate of 20 in. per minute (jaw speed) until it breaks. The test specimen shall break between the gage marks. The tensile strength shall be calculated upon the area of the original specimen.

Set Test Procedure.

31. The set test shall be made on a second test specimen having a length of not less than 6 in. and marked with gage marks 2 in. apart. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and shall be stretched at the rate of 20 in. per minute (jaw speed) until the gage marks are 6 in. apart. The test specimen shall then be released within 5 seconds and the distance between gage marks shall be determined 1 minute after the beginning of release. The set is the difference between this length and the original 2-in. gage length.

Elongation at Rupture Test Procedure.

32. The percentage of elongation at rupture shall be determined after the set test and on the same specimen. The specimen shall be placed in the jaws of the testing machine with a maximum distance between jaws of 4 in. and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the gage marks.

The elongation at rupture shall be taken as the distance between gage marks at rupture less 2 in. (the original gage length of the set test specimen). The percentage of elongation at rupture is the elongation in inches divided by the original gage length (2 in.) and multiplied by 100 to express as a percentage.

Retest.

33. When tested in accordance with Sections 30, 31 and 32, if a specimen fails to conform to any one of the requirements for tensile strength, set, or elongation at rupture specified in Section 16, two additional specimens shall be taken from the same sample and the average of the results shall determine whether the material conforms to the requirements.

Rejection.

34. When ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the results of such individual tests. Where the number of samples selected in any

inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of such individual tests.

THICKNESS

35. The thickness measurements may be made with any type of micrometer reading to 0.001 in., suitable for measurements of this character. **Apparatus.**

36. Where the lot of wire to be inspected consists of two coils or reels or less, at least one determination of the thickness shall be made on each coil or reel. Where the lot consists of more than two coils or reels and less than 20 coils or reels, at least one determination of the thickness shall be made on each of two coils or reels taken at random. If the lot consists of 20 or more coils or reels, not less than 10 per cent of the coils or reels shall be selected at random and at least one determination of the thickness made on each coil or reel so selected. **Number of Measurements.**

37. The average thickness of the insulation shall be taken as one-half the difference between the mean of the maximum and minimum diameters measured at any one point and the average diameter of the conductor measured at the same point. The minimum thickness shall be taken as the difference between a measurement made over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "slicing off" the heavier side of the insulation.) **Procedure.**

In the case of multiple-conductor cable, the measurements shall be made on the individual wires before being cabled.

38. If the thickness of the insulation of any coil or reel is found to be less than the specified value, that coil or reel shall be rejected and a thickness measurement on each of the remaining coils or reels shall be made. **Rejection.**

ELECTRICAL TESTS

39. Electrical tests of wire and cable shall be made at the place of manufacture. **Place.**

40. The high voltage test shall be made with alternating potential from a transformer and generator of ample capacity and in no case less than 5 kva. The frequency of the test voltage shall be not greater than 100 cycles and shall have a wave shape approximating as closely as possible a sine curve. **High Voltage Test.**

41. The initially-applied voltage shall be not greater than the rated voltage and the rate of increase shall be approximately uniform **Rate of Application.**

and not over 100 per cent in 10 seconds nor less than 100 per cent in 60 seconds.

Immersion in Water.

42. (*a*) The outer surface of the insulation of complete insulated wires and cables shall be grounded while being electrically tested. If the insulation is not provided with a conducting covering, and if the covering is not liable to injury by water, the ground shall be obtained by immersing the insulated wire or cable in water for at least 12 hours and testing at the end of that period while immersed. If the outer covering is susceptible to injury by immersion, the insulated conductor shall be tested before the application of such covering.

TABLE VI.—TEMPERATURE COEFFICIENTS.

Temperature		Temperature Coefficient	Temperature		Temperature Coefficient
Deg. Fahrenheit	Deg. Centigrade		Deg. Fahrenheit	Deg. Centigrade	
46	7.8	0.69	61	16.1	1.03
47	8.3	0.71	62	16.7	1.05
48	8.9	0.73	63	17.2	1.08
49	9.4	0.75	64	17.8	1.11
50	10.0	0.77	65	18.3	1.14
51	10.6	0.79	66	18.9	1.17
52	11.1	0.81	67	19.4	1.20
53	11.7	0.83	68	20.0	1.23
54	12.2	0.85	69	20.6	1.26
55	12.8	0.88	70	21.1	1.30
56	13.3	0.90	71	21.7	1.33
57	13.9	0.92	72	22.2	1.37
58	14.4	0.94	73	22.8	1.40
59	15.0	0.97	74	23.3	1.44
60	15.6	1.00	75	23.9	1.48

(*b*) In the case of multiple-conductor cables, without waterproof overall jacket of insulation, no immersion test shall be made on finished cables, but only on the individual conductors before assembling.

Application of Voltage.

43. (*a*) *Single-Conductor Cables.*—Single-conductor cables shall be tested between conductor and sheath or water in which they are immersed.

(*b*) *Multiple-Conductor Cables.*—If a multiple-conductor cable is rated at the same operating voltage between conductor and sheath or water as between conductors, each conductor shall be tested against the other conductors in the cable and against the sheath or water, at the test voltage prescribed for that rated voltage. If a cable is rated at a voltage between conductors and ground different from that between conductors, the test between conductors shall be based upon the rated voltage between conductors and the test between each conductor and sheath or water, shall be based on the rated voltage between conductors and sheath or water.

The several tests may be made by any arrangement of testing transformers suitable for the prescribed tests, such as one or more transformers supplied from a single-phase source or three transformers connected in star and supplied from a three-phase source.

Insulation Resistance.

44. (*a*) The insulation resistance shall be measured after the high-voltage test has been made and while the wire or cable is still immersed in water. The measurement shall be made after one-minute electrification with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained negative to the water. The temperature of the water shall be within the limits given in Table VII.

Temperature Coefficient.

(*b*) If the temperature at which the insulation resistance was measured differs from 60° F. (15.5° C.), the resistance shall be reduced to that at 60° F. (15.5° C.) by multiplying the measured value by the coefficient in Table VII corresponding to the temperature at which the measurement was made.

Rejection.

45. Each coil, reel or length which fails to comply with the electrical requirements specified in Sections 19 and 20 shall be rejected.

(*C*) CABLE TAPE

Material.

46. The tape shall be made from cotton cloth having a weight of not less than 1 lb. per 4 yd. with a width of 36 in. and not less than 56 by 60 picks per inch, and shall be frictioned on both sides and thoroughly filled with a rubber compound.

TABLE VIII.—WIDTH AND OVERLAP OF RUBBER-FILLED CABLE TAPE.

DIAMETER OVER INSULATION, IN.	MAXIMUM WIDTH OF TAPE, IN.	MINIMUM OVERLAP, IN.
2.00	4	½
1.75	3½	⅜
1.50	3	⅜
1.25	2½	⅜
1.15	2½	⅜
1.00	2	¼
0.88	2	¼
0.75	1½	¼
0.62	1½	¼
0.50	1	¼
0.38	1	¼
0.31	¾	⅛
0.25	¾	⅛
0.19	¾	⅛
0.16	¾	⅛

For intermediate diameters the requirements shall be those of the next smaller size.

Application.

47. The tape shall be applied helically. The maximum width and minimum overlap shall conform to the values in Table VIII.

Intermediate Diameters. 48. For intermediate diameters the requirements shall be those of the next smaller diameter indicated in Table VIII.

Number of Tests. 49. Samples shall be taken at the option of the purchaser.

(*D*) COTTON BRAID

Braid. 50. Cotton braids where specified shall be applied in accordance with Table IX.

TABLE IX.—THICKNESS AND WEAVE OF COTTON BRAID.

For twin cable, use the mean diameter.

Where two braids are specified, the outer braid shall be determined by the diameter after the first braid has been applied.

Equivalent braids having the same number of picks, the same thickness, and having a greater number of plies, will be accepted under these specifications.

This table does not apply to braids for fixture wire or for fancy or special braids.

Where two braids are applied with double deck braiders, this table shall apply to the outer and inner braids, except that the picks per inch and average angle of lay for the inner braid shall be governed by the construction of the machine.

A tolerance of 5 per cent below the value specified shall be allowed on both picks per inch and braid angles.

Diameter Under Braid, in.	Average Angle of Lay, deg.	Minimum Thickness of Braid, in.	Cotton Size, Ply and Ends	Average Picks, per Inch	Cotton Size, Ply and Ends	Average Picks per Inch
			12-Carrier Braiders		16-Carrier Braiders	
Less than 0.124	40	0.020	20/2/2	24	20/2/2	20
0.125 to 0.149	40	0.020	20/2/2	25	20/2/2	23
0.150 to 0.199	40	0.020	20/2/3	18	20/2/3	16
0.200 to 0.249	40	0.0225	....	....	16/2/3	15
0.250 to 0.299	40	0.0225	....	....	16/2/3	16
			20-Carrier Braiders		24-Carrier Braiders	
0.150 to 0.199	40	0.020	20/2/2	22	20/2/2	20
0.200 to 0.249	40	0.0225	16/2/2	20	16/2/2	20
0.250 to 0.299	40	0.0225	16/2/3	14	16/2/3	13
0.300 to 0.349	45	0.026	12/2/3	12	12/2/3	12
0.350 to 0.399	45	0.026	12/2/3	13	12/2/3	12
0.400 to 0.449	45	0.026	12/2/3	13	12/2/3	13
0.450 to 0.499	50	0.026	12/2/3	13	12/2/3	14
0.500 to 0.599	50	0.026	12/2/3	14	12/2/3	14
0.600 to 0.799	55	0.0315	....	....	8/2/3	12
0.800 to 0.999	60	0.0315	....	....	8/2/4	9.5
			36-Carrier Braiders		48-Carrier Braiders	
1.000 to 1.499	50	0.037	6/2/2	12	6/2/3	9.5
1.500 to 1.799	60	0.045	4/2/2	11.5	4/2/3	9.0
1.800 to 2.149	65	0.051	4/3/2	10.5	4/3/2	9.5
2.150 to 2.499	70	0.051	4/3/2	9.5	4/3/2	9.0
2.500 to 3.000	70	0.067	4/4/2	9.0	4/4/2	9.0

Coverings. 51. Wires up to No. 7 A. w. g. inclusive shall be covered with a single braid. On larger wires the fiberous coverings shall consist of a tape and a braid. In multiple conductor cables the individual conductors shall not be braided. If other coverings are desired, such as two braids in place of a tape and braid, it shall be so stated in the order.

The tape shall conform to Sections 46 to 49, inclusive, and the braid to Section 50.

Finish. 52. The braid shall be completely saturated with a weather-resisting compound and finished with a black waxy insulating compound thoroughly slicked down.

Compound. 53. The saturating and finishing compounds shall have no injurious effect upon the rubber insulation or the coverings at a temperature of 90° C. (194° F.) and shall meet the following tests:

(*a*) *Moisture Absorption Test.*—A 6-in. sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 20° C. (68° F.) for a period of 24 hours. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion.

(*b*) *Melt Test.*—A 6-in. sample of wire with the insulation removed for ½ in. at each end shall be placed on clean, white glazed paper and maintained at 52° C. (125° F.) for 30 minutes. The compound shall not migrate sufficiently to produce distinct marking on the paper. Markings produced by the sample at room temperature will be disregarded.

(*E*) LEAD SHEATHS

Composition. 54. Lead sheaths shall consist of commercially pure lead (approximately 99.85 per cent) without flaws and tightly formed about the taped core of the cable.

Thickness. 55. Lead sheaths shall have an average thickness not less than that indicated in Table X and the minimum thickness shall in no place be less than 90 per cent of the required average thickness.

TABLE X.—THICKNESS OF LEAD SHEATHS.

DIAMETER OF CORE, IN.[a]	THICKNESS OF SHEATH IN $\frac{1}{64}$ IN.
Over 3.000	9
2.001 to 3.000	8
1.501 to 2.000	7
1.051 to 1.500	6
0.701 to 1.050	5
0.426 to 0.700	4
0.000 to 0.425	3

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[a] For twin cables, use the major axis.

Measurement. 56. A short section of the lead sheath shall be removed from the wire or cable and the thickness measured with a suitable micrometer caliper at not less than ten points, approximately equally spaced, care being taken to include the thinnest and the thickest parts.

(*F*) INSPECTION

Inspection and Test.

57. (*a*) Inspection shall be made prior to shipment and at the place of manufacture.

(*b*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement of inspection.

(*c*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications.

(*d*) The purchaser at his option may make the various tests on samples in his own laboratory or elsewhere, but such tests shall be made at the expense of the purchaser.

Rehearing.

58. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX

Annealed Copper Standard[1]

The following shall be taken as normal values for standard annealed copper:

(*a*) *Resistance.*—At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 m. in length and of a uniform section of 1 sq. mm. is $\frac{1}{58}$ ohm = 0.017241 ohm.

(*b*) *Density.*—At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cu. cm.

(*c*) *Temperature Coefficient of Resistance.*—At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is 0.00393 = 1/254.45 per degree Centigrade.

(*d*) *Resistance of Standard Annealed Copper at 20° C.*—As a consequence, it follows from (*a*) and (*b*) that at a temperature of 20° C. the resistance of a wire of standard annealed copper of uniform section, 1 meter in length and weighing 1 g. is: $\frac{1}{58} \times 8.89 = 0.15328$ ohm.

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[1] Extracts from American Institute of Electrical Engineers' Standard No. 30.

TENTATIVE SPECIFICATIONS
FOR
RUBBER PUMP VALVES[1]

A.S.T.M. Designation: D 151 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover the requirements for rubber valves for pumps equipped with grid-type seats and which are used for pumping liquids having very slight, if any, effect on rubber.

Classes. 2. Rubber valves shall be furnished in three classes as specified, classification being made according to the service for which they are intended, as follows:

Class A.—Hard valves, for hot water at temperatures between 150 to 212° F. and at pressures between 200 and 300 lb. per sq. in.

Class B.—Medium valves, for water at temperatures less than 170° F. and at pressures between 50 and 200 lb. per sq. in.

Class C.—Soft valves, for water at temperatures less than 170° F. and at pressures less than 50 lb. per sq. in.

MANUFACTURE

Material. 3. The valves shall consist of properly vulcanized rubber compound and the compound shall contain no rubber substitute of any kind, nor reclaimed rubber, and shall be free from all substances which might injuriously affect its quality.

CHEMICAL COMPOSITION AND TESTS

Chemical Composition. 4. The compound shall contain not less than the following percentages by volume of the best quality new wild or plantation rubber:

	RUBBER, MINIMUM PER CENT BY VOLUME
Class A, Hard	55
Class B, Medium	60
Class C, Soft	65

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

Chemical Analysis.

5. Chemical analysis of the compound shall be made in accordance with the Short Procedure described in Sections 1 to 13 of the Tentative Methods of Chemical Analysis of Rubber Products (A.S.T.M. Designation: D 297 - 31 T) of the American Society for Testing Materials.[1]

PHYSICAL PROPERTIES AND TESTS

Hardness.

6. (*a*) The valves shall conform to the following requirements as to hardness when tested in accordance with Paragraph (*b*):

	Hardness	
	Minimum	Maximum
Class A, Hard	0.03 mm.	0.15 mm.
Class B, Medium	0.50 mm.	0.75 mm.
Class C, Soft	0.80 mm.	1.05 mm.

(*b*) The hardness shall be measured by determining the depth of indentation in millimeters produced by a spherical surface 3.2 mm. (0.125 in.) in diameter under a dead-weight pressure of 1 kg. (2.2 lb.) applied for one minute. The test shall be made at a temperature not under 60° F. nor over 80° F.

Heat Tests.

7. Valves when cut in half and subjected to the following dry heat and steam tests shall not show any disintegration, blistering or other defects either on the surfaces or in the interior when cut open.

(*a*) *Dry Heat Test:* One-half valve shall be exposed to dry heat at 270° F. ± 5° F. for one hour.

(*b*) *Steam Test:* One-half valve shall be exposed to steam at 400° F. ± 5° F. for three hours, the steam pressure to be gradually reduced to atmospheric pressure at the end of the test.

Number of Specimens.

8. For purposes of test, one valve representing each class shall be selected from each order.

DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions.

9. The thickness shall be uniform throughout and the entire circumference shall be concentric with the hole at the center.

Permissible Variations.

10. Tolerances of $\pm \frac{1}{32}$ in. in thickness and diameter shall be permissible.

WORKMANSHIP AND FINISH

Workmanship and Finish.

11. Surfaces of all valves shall be smooth and free from pitting, blisters, air checks and other imperfections.

MARKING

Marking.

12. Each valve shall be branded on the edge with the name of the manufacturer, the month and year of manufacture and the word "hard," "medium" or "soft."

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[1] See p. 947.

INSPECTION

Inspection and Tests.

13. (*a*) The purchaser may make the inspections and tests to govern the acceptance or rejection of the valves in his own laboratory or elsewhere, but such inspections and tests shall be made at the expense of the purchaser.

(*b*) If the inspections and tests are made at the place of manufacture, the manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the valves are being furnished in accordance with these specifications. Such inspections and tests shall be so conducted as not to interfere unnecessarily with the operation of the works.

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
RUBBER PRODUCTS[1]

A.S.T.M. Designation: D 297 – 31 T

This is a **Tentative Standard**, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1928; REVISED, 1929, 1931.

(*A*) *Short Procedure*

GENERAL INSTRUCTIONS

Blanks. 1. Blank tests shall be run on all determinations and deductions made accordingly.

Checks. 2. In the event of any determination not falling within the limits given in these methods of test, a duplicate determination which shall agree within the limits specified shall be made and the average value taken as the true value.

Preparation of Specimen. 3. (*a*) A specimen weighing not less than 15 g. shall be prepared, taking pieces from various parts of the sample.

(*b*) The specimen shall be cut into small pieces and run through a grinder until all of it will pass through a No. 20 sieve.[2] Care must be taken that the grinder does not become appreciably warm. The backing shall be buffed off before grinding.

Removal of Iron and Care of Specimen. 4. A strong magnet shall be passed through the specimen to remove any metal from the grinder, and the specimen shall be mixed thoroughly and put in tightly stoppered bottles. It shall not be exposed to sunlight or heat.

REAGENTS

5. (*a*) *General Requirements.*—All reagents shall be of a purity equal to that called for in Krauch's "Standard Chemical Reagents, Their Purity and Use."

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

These methods are essentially those adopted as standard by the American Chemical Society and the U. S. Bureau of Standards and include the Joint Rubber Insulation Committee's Procedure.

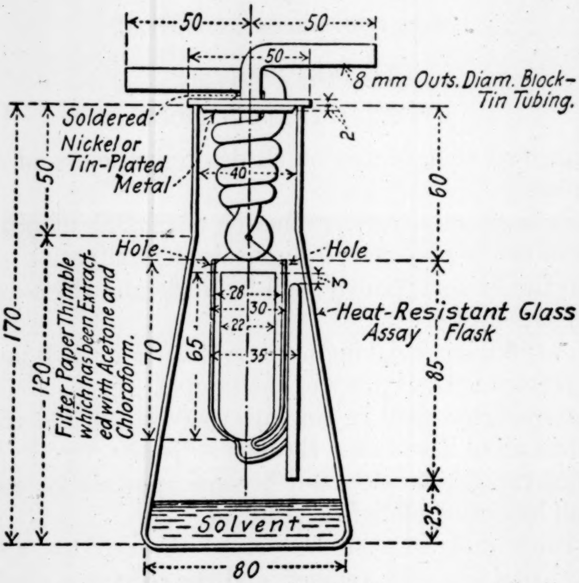
These methods will supersede, when adopted, the Chemical Tests appearing in Sections 1 to 47, inclusive, of the Standard Methods of Testing Rubber Products (A.S.T.M. Designation: D 15 – 24), 1930 Book of A.S.T.M. Standards, Part II, p. 1040.

[2] For detailed specifications for this sieve, see the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation; E 11) of the American Society for Testing Materials, 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

(*b*) *Acetone.*—Acetone shall be distilled not more than 10 days before use over anhydrous potassium carbonate, using the fraction which distills at 56 to 57° C.

(*c*) *Alcoholic-Potash Solution.*—Alcoholic potash shall be of normal strength, made by dissolving the required amount of KOH in absolute alcohol the day before use, and allowing to settle. Only the clear solution shall be used.

(*d*) *Barium-Chloride Solution.*—Barium-chloride solution shall be made by dissolving 100 g. of crystallized barium chloride in one liter of distilled water and adding two or three drops of concentrated HCl. If there is any insoluble matter or cloudiness, the solution shall be heated over night on the steam bath and filtered.


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
Soldered
Nickel or Tin-Plated Metal
40
2
50
60
170
120
Hole
Hole
3
28
30
22
35
Heat-Resistant Glass Assay Flask
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
70
65
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 1.—Extraction Apparatus.

METHODS OF ANALYSES

ACETONE EXTRACT

Extraction Apparatus. 6. The extraction apparatus shall conform to that shown in Fig. 1. It shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between 2½ and 3½ minutes.

Procedure.

7. Two grams of the rubber shall be extracted continuously with acetone for 8 hours, using a sample that has been prepared within 24 hours. Distill off the acetone and dry the flask and contents for 4 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down from the side of the flask.

FREE SULFUR

Free Sulfur.

8. Add to the flask containing the acetone extract 50 to 60 cc. of distilled water and 2 or 3 cc. of bromine (if the acetone extract indicates a large amount of free sulfur, the amount of bromine should be increased). Heat gently on the steam bath until the solution is practically colorless and filter into a 400-cc. beaker. Dilute with distilled water until the volume is about 400 cc. Cover the beaker with a watch glass, heat to boiling on the steam bath, add 10 cc. of barium-chloride solution (10-per-cent) and allow the precipitate to stand over night. The next day filter off the precipitate, ignite the filter paper and weigh.

ALCOHOLIC-POTASH EXTRACT

Alcoholic-Potash Extract.

9. Dry the residue from the acetone extraction at 50 to 60° C., put into a 200-cc. Erlenmeyer flask with 50 cc. of the alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution into a beaker and wash twice, using each time 25 cc. of hot absolute alcohol and then wash thoroughly with hot water. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. of 5 *N* HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool, add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

TOTAL SULFUR

Total Sulfur.

10. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion. Then bring to quiet fusion for 15 to 20 minutes, applying heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate if silica is present; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 400 cc. Heat to boiling and add slowly a slight excess of hot barium-chloride solution (10-per-cent). Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

ASH

Ash.

11. Weigh out a 1-g. sample in a porcelain crucible, heat in a muffle furnace, the temperature of which is carefully regulated so that no material amount of visible products are given off. After the mass is charred, the temperature shall be raised sufficiently to burn the carbon. The whole process shall be conducted at as low a temperature as possible. At the end of this operation the crucible shall be removed from the furnace, cooled in a desiccator and weighed; the ash broken up and inspected for carbon. If any visible carbon is present, a new determination shall be conducted.

CALCULATIONS

Calculations.

12. The percentage of rubber shall be considered to be the difference between 100 and the sum of the total sulfur and ash expressed as percentages and figured on the total compound. If the alcoholic-potash extract is over 2 per cent of the rubber as first calculated, subtract this excess also from the rubber. The organic-acetone extract shall be obtained by taking the difference between the total acetone extract and the free sulfur. The organic-acetone extract, free sulfur, total sulfur and alcoholic-potash extract shall be figured on the amount of gum as found by the above procedure.

CHECK ANALYSES

Check Analyses.

13. Duplicate determinations when required shall check within the following limits, expressed as percentages of the gum present, as found by analysis, except as stated:

	CHECK WITHIN, PER CENT
Organic-acetone extract	0.20
Free sulfur	0.10
Total sulfur	0.10
Alcoholic-potash extract	0.10
Ash calculated on total compound	0.25

(*B*) *Complete Procedure*

Scope.

14. These methods cover the complete procedure of analysis of rubber products to determine whether they comply chemically with specifications which are intended to secure compounds containing 30 per cent of the best Hevea rubber, and mineral fillers. In addition, there is a method which employs a solvent for the vulcanized rubber. This method has proved to be more accurate than an ash determination when carbonates are present in a rubber compound and may also be used in the analysis of asbestos rubber packings and rubberized fabrics.

DEFINITIONS

Definitions.

15. (*a*) *Acetone Extract.*—If the acetone extraction is made on vulcanized compound, the acetone removes the rubber resins, the free sulfur, any mineral oils or waxes, any acetone-soluble antioxidants and organic accelerators or their decomposition products and part of any bituminous substances or vulcanized oils that may have been used. This is generally called acetone extract uncorrected. The percentage of free sulfur and the percentage of waxy hydrocarbons are determined and their sum deducted from the total extract. The value obtained is known as acetone extract corrected. The corrected figure thus obtained will at times give valuable information regarding the quality of the rubber present. This is not true, however, when the compound contains substantial quantities of mineral oils or waxes, bituminous substances, organic accelerators or antioxidants which have been added. With compounds containing rubber value which consists of only the best grades of Hevea rubber the acetone extract should not exceed 5 per cent of the rubber present. A higher extract may indicate the presence of inferior or reclaimed rubbers, added oils, waxes or bituminous materials or substantial quantities of organic accelerators or antioxidants. No correction is possible for small quantities of antioxidants and organic accelerators, since no general method is now known for the separation and identification of all classes of these materials.

(*b*) *Chloroform Extract.*—The chloroform extraction removes a portion of the bituminous substances and serves as an indication of their presence. The chloroform extract may also include other materials.

(*c*) *Alcoholic-Potash Extract.*—The purpose of the alcoholic-potash extraction is to detect the presence of rubber substitutes.

(*d*) *Free Sulfur.*—Free sulfur is that which is removed during the acetone extraction.

(*e*) *Total Sulfur.*—Total sulfur is the sulfur that occurs in the compound, either free or chemically combined, unless barium sulfate is present, in which case the amount of sulfur in it is deducted from the amount of total sulfur.

(*f*) *Ash.*—The ash is the residue left after ignition and consists principally of the non-volatile mineral fillers, together with their reaction products with sulfur.

(*g*) *Sulfur in Ash.*—The sulfur in ash consists of the sulfur from the mineral fillers and also part of the sulfur that was with the rubber, but which during ignition enters into combination with mineral fillers.

(*h*) *Total Compounding Ingredients.*—Total compounding ingredients consist of the residue obtained when the rubber is dissolved by mineral oil in the solution method of analysis. Total compounding ingredients corrected is the value obtained after deducting sulfur and organic matter present.

Special Determinations. 16. Special methods are given for the analysis of compounds that contain glue, carbon, antimony, and waxy hydrocarbons.

Indirect Methods. 17. (*a*) Up to the present time, no simple method has been devised for the direct determination of the amount of rubber present in a vulcanized compound. Therefore, an indirect method is proposed which will give satisfactory results in all cases known today, except where there are found to be present decomposible compounding ingredients, such as carbonates, cellulose, and high percentages of mineral rubbers. As practically all insulating compounds contain some of these ingredients, the said compounds when specified shall be analyzed in accordance with the Joint Rubber Insulation Committee's Procedure as described in Section 45.

(*b*) When carbonates, talc, and asbestine are present more accurate results are obtained by the use of the Joint Rubber Insulation Committee's Procedure described in Section 45, or by the Rubber Solvent Method described in Sections 57 to 60, inclusive.

(*c*) If high percentages of mineral rubber are used, no accurate method is known. If cellulose is present the best results are obtained by the method described in Section 46.

REAGENTS

Reagents.

18. (*a*) *Acetone.*—The acetone shall be chemically pure and shall be freshly redistilled over anhydrous sodium carbonate, using the 56 to 57° C. fraction.

(*b*) *Alcoholic-Potash Solution.*—The alcoholic-potash solution shall be of normal strength. It shall be made by dissolving the required amount of KOH in alcohol which has been purified as follows:

Dissolve 1.5 g. of $AgNO_3$ in 3 cc. of water and add it to 1000 cc. of alcohol. Dissolve 3 g. of KOH in the smallest amount of hot water, cool, add it to the alcoholic-silver nitrate solution, and shake thoroughly. Allow the solution to stand for at least 24 hours, filter, and distill. (Alcohol denatured with 10 per cent by volume of methanol may be used in place of ethyl alcohol.)

(*c*) *Nitric Acid-Bromine Solution.*—The nitric acid-bromine solution shall be prepared by adding a considerable excess of bromine to concentrated HNO_3 and shaking thoroughly.

(*d*) *Zinc - Nitric Acid Solution.*– The zinc-nitric acid solution is made by adding 200 g. of zinc oxide to 1000 cc. of concentrated HNO_3.

(*e*) *Barium-Chloride Solution.*—Barium-chloride solution shall be made by dissolving 100 g. of crystallized barium chloride in 1 liter of distilled water, and adding two to three drops of concentrated HCl. If there is any insoluble matter or cloudiness, the solution shall be heated overnight on the steam bath and filtered.

(*f*) *Standard 0.1 N Potassium Permanganate Solution.*—Dissolve approximately 3.1 g. of potassium permanganate in 1 liter of water, and after about one month filter through an ignited asbestos pad. Weigh 0.25 g. of pure metallic antimony and transfer it to a 600-cc. Erlenmeyer flask. Add 12 to 15 cc. of concentrated H_2SO_4, 10 to 12 g. of potassium sulfate, and heat until all the antimony is dissolved. Dilute to 250 cc. with water, add 20 cc. of concentrated HCl, cool to 10 to 15° C., and titrate with permanganate solution until a faint pink color is obtained.

$$1 \text{ cc. of } 0.1\,N\,KMnO_4 = \frac{\text{Wt. of metallic antimony}}{\text{cubic centimeters of permanganate}}$$

(*g*) *Starch Iodate Paper.*—Starch iodate paper is prepared by impregnating filter paper with a solution obtained by heating 2 g. of starch with 100 cc. of water and, after solution, adding 0.2 g. of potassium iodate dissolved in 5 cc. of water.

(*h*) *Rubber Solvent.*—The mineral oil used in the solution method of determining rubber and fillers shall have approximately the following properties: Vicosity at 68° F., 56 seconds; at 100° F., 45 seconds; flash point 270° F.; fire point 350° F.; and specific gravity 0.853, and shall be colorless.

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(*i*) *Asbestos Gooch Crucible.*—Prepare a Gooch crucible in the following manner: Amphibole asbestos is cut fine with shears, digested with caustic-soda solution (10-per-cent), washed with water, and then digested with concentrated HCl for a few hours on the steam bath. After it has been washed comparatively free from acid by decantation, the asbestos is shaken up with water and the resulting mixture is used in preparing the pad. The Gooch crucible is ignited, and is then ready for use.

BLANK ANALYSES

Blank Analyses.

19. The purity of all materials shall be checked and determined by blank analyses.

PREPARATION OF SAMPLES

Preparation of Samples.

20. (*a*) Before preparing a sample for analysis the analyst shall, by inspection, assure himself that it has not been contaminated. The sample shall be prepared by taking pieces from various parts of the original sample and separating them from foreign matter. The rubber shall be ground to the required fineness on a rubber mill or cut with scissors so as to pass a No. 14 sieve. Hard rubber should be prepared by rasping with a coarse file, cleaning with a magnet, and passing through a No. 14 sieve.

(*b*) Crude, reclaimed, or unvulcanized rubber shall be sheeted out very thin on an experimental mill and shall be rolled in holland or other cotton cloth to prevent the sample from sticking. If no mill is available, the sample shall be cut with scissors as fine as possible.

(*c*) Samples of rubberized cloth shall be prepared by cutting into pieces, 1.5 mm. square, and then mixing well.

(*d*) *Cements.*—Evaporate to dryness in a vacuum and analyze the residue as an unvulcanized sample. Distill a separate sample under reduced pressure if examination of the solvent is desired.

PRELIMINARY EXAMINATION OF SAMPLE

Carbonates.

21. Drop a small piece of the sample into a test tube containing concentrated HCl saturated with bromine. If a stream of bubbles is given off, the Rubber Solvent Method described in Sections 57 to 60, inclusive, shall be used.

Antimony.

22. Place a portion of the sample in a porcelain crucible and burn off the rubber. Treat the ash with concentrated HCl. Dilute the solution to 10 times its volume, filter and saturate with H_2S. If a precipitate of antimony sulfide is formed, the method described in Section 38 or the Rubber Solvent Method in Sections 57 to 60, inclusive, should be used.

23. Heat a portion of the sample with concentrated HNO_3 until there is no more frothing. If the liquid is black, it indicates the presence of free carbon, and the test for this substance should be made. **Carbon Black.**

24. A qualitative test for barium can conveniently be made on the residue after filtration in the total sulfur determination as described in Section 33, by dissolving it in HCl (10-per-cent), filtering and then adding a few drops of H_2SO_4 (10-per-cent). A white precipitate of barium sulfate indicates the presence of barium in the sample. **Barium Salts.**

25. If paraffin is present, it will solidify in the cold acetone extract as a white flucculent precipitate clinging to the sides of the flask. **Paraffin.**

26. Extract a portion of the sample with a mixture of 32 per cent acetone and 68 per cent chloroform by volume for 8 hours. Dry the sample and digest for 1 hour with hot water. Filter, cool, and add a few drops of a freshly prepared solution of tannic acid (2-per-cent) and allow to stand for a few minutes. If the solution becomes turbid, glue is present and should be determined as described in Section 41. **Glue.**

METHODS OF ANALYSES

SPECIFIC GRAVITY

27. Specific gravity shall be determined by the use of a pycnometer, using alcohol in place of water, to eliminate the errors due to air bubbles: **Specific Gravity.**

$$\text{Sp. gr.} = \frac{C}{C - (B - A)} \times \text{sp. gr. of alcohol}$$

where A = weight of the pycnometer filled with alcohol,
B = weight of the pycnometer filled with sample and alcohol,
C = weight of the sample.

ACETONE EXTRACT

28. The extraction apparatus used here and for other extractions shall be of the type shown in Fig. 1. The flask shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between 2.5 and 3.5 minutes. **Extraction Apparatus.**

29. Place 2 g. of rubber in a thimble made by folding a filter paper so that it will fit in the extraction cup, which is suspended in a weighed extraction flask. Extract the sample continuously for 8 hours, unless the solution in the thimble is still colored at the end of that time, when the extraction shall proceed for a further period of 4 hours or longer. For hard rubber the extraction period shall be a minimum of 72 hours. Carefully note all characteristics of the acetone extract, both when hot and cold. Distill off the acetone on a steam bath, recovering the acetone if desirable, at as low a tem- **Procedure.**

perature as possible. Loss of extract by bumping can be avoided by means of a gentle current of air. Care must be taken to avoid allowing the flasks to stand on the steam bath after the solvent has been removed, because appreciable quantities of free sulfur may be lost by so doing. Dry the extraction flask and contents in an air bath for 1 hour at 70° C., cool, and weigh. Call the residue "acetone extract, uncorrected." Keep the sample for future determinations.

$$\text{Percentage of acetone extract, uncorrected} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

CHLOROFORM EXTRACT

Chloroform Extract.

30. The rubber sample (see Sections 28 and 29) is suspended in a second weighed extraction flask and extracted for 4 hours with chloroform. Care should be taken that any small particles of rubber, which are often carried down into the extract, are filtered off. Evaporate off the solvent and dry to constant weight, usually 1 hour at 70° C., cool, and weigh. The color of the chloroform solution should be recorded. Reserve the rubber for extraction with alcoholic potash.

$$\text{Percentage of chloroform extract} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

ALCOHOLIC-POTASH EXTRACT

Alcoholic-Potash Extract.

31. Dry the rubber from the chloroform extraction at about 70° C. to remove the chloroform, transfer to a 200-cc. Erlenmeyer flask, add 50 cc. of alcoholic-potash solution, and heat under a reflux condenser for 4 hours. Filter into a 250-cc. beaker, wash with two 25-cc. portions of boiling alcohol; then with three 25-cc. portions of boiling water, and evaporate the filtrate just to dryness. Use about 75 cc. of distilled water to transfer the residue to a separatory funnel. Acidify the solution with HCl (10-per-cent), testing with Congo red paper. Extract with four 25-cc. portions of ether, unless the fourth portion should be colored, when the extraction must be continued until no further quantity can be removed. Unite the ether fractions and wash thoroughly with distilled water until free from acid (two washings are generally sufficient). Filter the ether solution through a plug of absorbent cotton into a weighed flask, wash with ether, evaporate, dry to constant weight at 70° C., cool, and weigh.

$$\text{Percentage of alcoholic-potash extract} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

FREE SULFUR

Free Sulfur

32. Add to the flask containing the acetone extract, uncorrected (Sections 28 and 29), 60 cc. of distilled water and 2 to 3 cc. of bromine,

and cover with a watch glass. Allow the flask to stand 30 minutes on the side of the steam bath, then heat cautiously over the direct steam bath until the solution is practically colorless, filter into a 250-cc. beaker, and dilute to about 175 cc. with distilled water. Precipitate with barium chloride and determine in the usual manner.

$$\text{Percentage of free sulfur} = \frac{\text{Wt. of BaSO}_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

TOTAL SULFUR

Total Sulfur, Recommended Method.

33. Place 0.5 g. of rubber in a porcelain crucible of about 75-cc. capacity, add 15 cc. of the nitric acid-bromine mixture, cover the crucible with a watch glass, and let it stand for 1 hour in the cold. Heat for 1 hour on the steam bath, remove the cover, rinse it with a little distilled water, and evaporate to dryness. Add 3 cc. of HNO_3, cover, warm a short time on the steam bath, then let it cool. Carefully add in small portions, by means of a glass spatula, 5 g. of sodium carbonate (weighed to 0.5 g.). The watch glass is to be raised only high enough to permit the introduction of the spatula. The carbonate is allowed to slide down the side of the crucible and is not dropped directly into the acid. Rinse the watch glass with 2 or 3 cc. of hot distilled water and stir the mixture thoroughly with a glass rod. Digest for a few minutes, spread the mixture halfway up the side of the crucible to facilitate drying, and dry on a steam bath. Fuse the mixture by heating over a sulfur-free gasoline flame.

Place the crucible in an inclined position on a wire triangle and start the ignition over a low flame. The tendency for the organic matter to burn too briskly is controlled by judicious use of the stirring rod with which the burning portion is scraped away from the rest. When part of the mass is burned white, a fresh portion is worked into it until all of the organic matter is destroyed. It is necessary to hold the edge of the crucible with tongs. Toward the last half of the operation the flame should be increased. It is unnecessary to heat the crucible to redness. With care, a crucible can be used for at least 10 to 12 fusions.

After a fusion, allow the crucible to cool, place it in a 400-cc. beaker, add sufficient distilled water to cover the crucible (about 125 cc.), and digest on the steam bath for 2 hours, with occasional stirring. If the filtration can not be made on the same day, do not add the water, but allow the fusion to stand overnight.

Filter the solution into a covered 400-cc. beaker containing 5 cc. of concentrated HCl, and wash the residue thoroughly with hot water. (A qualitative test for barium can be made on the residue.) Complete the acidification of the filtrate and washings and add 2 cc. of concentrated HCl in excess. Cover the beaker and heat the solution on the steam bath. The total volume of the solution should be 300 cc. The solution must be acid to Congo paper in order to insure the complete destruction of the carbonates. Precipitate with barium chloride and determine the sulfur in the usual manner.

$$\text{Percentage of total sulfur} = \frac{\text{Wt. of } BaSO_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

Total Sulfur, Alternate Method.

34. *Alternate Method.*—When this method is used the total sulfur determined represents the sulfur exclusive of that originally present as barytes or formed from barium salts, if present in the compound.

Place a 0.5-g. sample in a 500-cc. Erlenmeyer destruction flask of Pyrex glass, quartz or similarly resistant material. Add 10 cc. of zinc oxide-nitric acid solution and moisten the sample thoroughly. If convenient, the mixture may be allowed to stand overnight. By so doing the sample becomes partly decomposed; this permits the addition of fuming HNO_3 with no danger of ignition of the sample. Add 15 cc. of fuming HNO_3 and whirl the flask rapidly to keep the sample immersed to avoid ignition by too rapid oxidation. With some samples it will be found necessary to cool the flask under a stream of tap water.

When the solution of the rubber is complete, add 5 cc. of a saturated water solution of bromine and slowly evaporate the mixture to a foamy sirup. (For the determination of total sulfur in unvulcanized mixtures use 3 cc. of bromine in place of bromine water.)

If particles of organic matter remain at the end of the evaporation, add a few cubic centimeters of fuming HNO_3 and re-evaporate as before. Cool, and add a few crystals of potassium chlorate to assist in the oxidation of the sulfur and the decomposition of any nitrates.

Place the flask on asbestos gauze and evaporate the mixture to dryness over a Tirrill burner. Then bake the mixture at the highest temperature of the burner until all nitrates are decomposed and no more nitrogen peroxide fumes can be detected. When the baking is complete, cool the flask, add 50 cc. of HCl (1:6) and heat until solution is complete. (In case the original mixture contains barium sulfate or other barium salts, they will be precipitated at this point with consequent loss of sulfur in the case of the latter. If litharge is present in the mixture, lead salts, not otherwise removed, will be eliminated in the final washing with boiling water.) Filter the solution, dilute to 300 cc., precipitate with barium chloride, and determine the sulfur in the usual manner.

$$\text{Percentage of total sulfur} = \frac{\text{Wt. of BaSO}_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

ASH

Ash. 35. Wrap a 1-g. sample in a filter paper, extract with acetone for 4 hours, and transfer to a weighed, approximately 50-cc. porcelain crucible. Ash the sample in a muffle furnace by heating at the following rate:

Time, minutes....................	0	5	10	15	70	75	80	85	145
Temperature, deg. Centigrade......	0	100	200	300	300	400	500	550	550

Remove the crucible from the furnace, cool, and weigh.

$$\text{Percentage of ash} = \frac{\text{Wt. of ash}}{\text{Wt. of sample}} \times 100$$

If no furnace is available, distill off the rubber over a very small flame, not allowing it to catch fire, and ignite gently until burnt clean, cool, weigh, and determine ash in the usual manner.

SULFUR IN ASH

Sulfur in Ash. 36. Add 3 cc. of nitric acid - bromine mixture to the ash (see Section 35), cover with a watch glass and heat for 1 hour, remove the cover, rinse it with a little distilled water, and evaporate to dryness. Complete the determination of sulfur as described in Section 33.

Save the insoluble residue, after filtering the solution of the fusion mixture in water, for testing in accordance with Section 37.

SULFUR AS BARIUM SULFATE

Sulfur as Barium Sulfate. 37. The barium sulfate is calculated from the barium in the ash, which is determined as follows: Filter off the insoluble matter after the fusion and extraction described in Section 36, wash back into the original beaker with hot water, dissolve the residue in the beaker and any traces on the filter paper with HCl, and heat the solution on the steam bath. Filter through the same filter as before and wash thoroughly with hot water. Nearly neutralize the solution with NH_4OH, leaving it slightly acid. Saturate the cold solution with H_2S, and when the lead sulfide has settled, filter into a 400-cc. beaker and wash thoroughly. The total volume should be not over 200 cc. Precipitate with H_2SO_4 (10-per-cent) and determine the sulfur in the usual manner. Barium sulfate determined above is assumed to have been added as such. Obviously, if barium carbonate is present, it must be determined in order that an undue correction will not be made.

$$\text{Percentage of sulfur as barium sulfate} = \frac{\text{Wt. of BaSO}_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

TOTAL ANTIMONY

Total Antimony.

38. When a qualitative test indicates that antimony is present, weigh out a 0.5-g. sample, and transfer to a Kjeldahl flask, add 25 cc. of concentrated H_2SO_4 and 10 to 12 g. of potassium sulfate, place a funnel in the neck of the flask, and heat until the solution becomes colorless. Cool and wash the funnel, dilute the solution to 100 cc. with water, and transfer to a 400-cc. beaker, dilute to 250 cc. with hot water, and precipitate the antimony with H_2S. Filter and transfer the precipitate to a Kjeldahl flask, add 15 cc. of concentrated H_2SO_4, 10 to 12 g. of potassium sulfate, and heat as described above until the solution is colorless. Wash the funnel, dilute the solution to 100 cc. with water, add 1 to 2 g. of sodium sulfite, and boil until all the sulfur dioxide is driven out.

This is shown when no blue color is obtained with starch iodate paper. Add 20 cc. of concentrated HCl, dilute to 250 to 275 cc. with water, cool to 10 to 15° C., and titrate with standard 0.1 *N* permanganate solution until a faint pink color is obtained. If iron is found to be absent it is not necessary to precipitate the antimony with H_2S and the second heating in a Kjeldahl flask may be eliminated.

$$\text{Percentage of antimony} = \frac{\text{Sb (see Section 18 } (f)) \times \text{cubic centimeters of permanganate}}{\text{Wt. of sample}} \times 100$$

ANTIMONY IN THE ASH

Antimony in the Ash.

39. Antimony in the ash is determined on the ash of a 1-g. sample as follows: Transfer the ash to a 600-cc. Erlenmeyer flask, add 12 to 15 cc. of concentrated H_2SO_4 and 10 to 12 g. of potassium sulfate, and boil until solution is complete. It may be necessary to warm part of the H_2SO_4 in the crucible to transfer any adhering particles to the flask. Rinse with the remaining portion of acid. Then complete the determination as described in Section 38.

$$\text{Percentage of antimony as Sb}_2\text{O}_4 \text{ in ash} = \frac{\text{Sb (see Section 18 } (f)) \times \text{cubic centimeters of permanganate} \times 1.26}{\text{Wt. of sample}} \times 100$$

FREE CARBON

Free Carbon.

40. Extract a 0.5-g. sample for 8 hours with a mixture of 68 per cent chloroform and 32 per cent acetone by volume.

Transfer the sample to a 250-cc. beaker and heat on the steam bath until it no longer smells of chloroform. Add a few cubic centimeters of concentrated HNO_3 and allow to stand for about 10 minutes. Add 50 cc. more of concentrated HNO_3, taking care to wash down the sides of the beaker, and heat on the steam bath for at least 1 hour. At the end of this time there should be no more bubbles or foam on the surface. Pour the liquid while hot into a Gooch crucible, taking care to keep as much as possible of the insoluble material in the beaker. Filter slowly with gentle suction and wash well by decantation with hot concentrated HNO_3. Wash with acetone and a mixture of equal parts of acetone and chloroform until the filtrate is colorless. Digest the insoluble material, which has been carefully retained in the beaker, for 30 minutes on the steam bath with 35 cc. of sodium hydroxide solution (25-per-cent). This treatment with alkali may be omitted if silicates are absent. Dilute to 60 cc. with hot distilled water and heat on the steam bath. Filter the solution of alkali and wash well with hot sodium hydroxide solution (15-per-cent).

Next, wash the residue about four times with hot concentrated HCl. Neutralize the last washing with NH_4OH and test for the presence of lead with sodium chromate solution. If lead is present continue to wash with hot concentrated HCl and, finally, wash with warm HCl (5-per-cent). Remove the crucible from the funnel, taking care that the outside is perfectly clean, dry it in an air bath for 1½ hours at 110° C., cool, weigh, burn off the carbon at a dull red heat, and reweigh. The difference in weight represents approximately 105 per cent of the carbon originally present in the form of lampblack or gas black.

$$\text{Percentage of free carbon} = \frac{\begin{matrix}\text{Wt. of crucible} \\ \text{with carbon}\end{matrix} - \begin{matrix}\text{Wt. of crucible} \\ \text{after ignition}\end{matrix}}{1.05 \times \text{Wt. of sample}} \times 100$$

NITROGEN CALCULATED AS GLUE

Nitrogen Calculated as Glue.

41. When glue is found to be present, a correction must be made for the natural protein in the rubber. The average amount of nitrogen is 0.4 per cent. See Section 49 for calculations.

Extract a 2-g. sample for 8 hours with acetone. Remove the solvent from the sample, and transfer the latter from the filter paper to a 750-cc. Kjeldahl flask. Add 25 to 30 cc. of concentrated H_2SO_4, 10 to 12 g. of sodium sulfate, and about 1 g. of copper sulfate. Heat gently until the first vigorous frothing ceases, then raise the heat gradually until the liquid boils. Continue the boiling until the solution becomes clear. Allow the flask to cool, dilute carefully with 150 cc. of water, and again allow to cool. Add 100 cc. of sodium hydroxide solution (50-per-cent), pouring it carefully down the side of the flask, so that it does not mix immediately with the acid solution. Add about 1 g. of granulated zinc to prevent bumping and a piece of paraffin the size of a pea to diminish frothing. Connect the flask quickly with a condenser, the delivery tube of which dips into a 500-cc. Erlenmeyer flask, containing 50-cc. of 0.1 *N* H_2SO_4 diluted to about 100 cc. Carefully swirl the flask to mix the contents and start to heat gently, increase the flame as the danger of foaming over diminishes, and finally boil briskly until about one-half of the liquid has passed over into the receiver. Add methyl red solution and titrate the excess acid by means of 0.1 *N* NaOH solution. A blank determination should be made.

$$\text{Percentage of nitrogen as glue} = \frac{100\ (H_2SO_4 \times \text{normality} - \text{NaOH} \times \text{normality})\ (0.014)\ (6.5)}{\text{Wt. of sample}}$$

When a 2-g. sample is used this formula becomes:

$$\text{Percentage of nitrogen as glue} = (H_2SO_4 \times \text{normality} - \text{NaOH} \times \text{normality}) \times 4.55$$

UNSAPONIFIABLE MATTER

Unsaponifiable Matter.

42. If this determination is made the free sulfur shall be determined on a separate 2-g. sample.

Add to the acetone extract obtained from two 2-g. samples (see Section 29), 50 cc. of *N* alcoholic-potash solution, heat on the steam bath under a reflux condenser for 2 hours, remove the condenser and evaporate to dryness. Transfer to a separatory funnel, using about 100 cc. of water, add 25 cc. of ether, and shake. Allow the two layers to separate thoroughly, then draw off the water layer. Continue the extraction of the water layer with fresh portions of ether until no more unsaponifiable matter is removed, unite the ether layers, and wash with distilled water. Transfer the ether to a weighed flask, distill off the ether, dry to constant weight at 70° C., cool, and weigh.

$$\text{Percentage of unsaponifiable matter} = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

HYDROCARBONS *A*

Hydrocarbons A.

43. To the unsaponifiable matter (see Section 42), add 50 cc. of absolute alcohol, and heat on the steam bath for 30 minutes. Let the flask stand in a mixture of ice and salt for 1 hour. Filter off the separated waxy hydrocarbons on filter paper, by applying a gentle suction. Wash with alcohol (95-per-cent) which has been cooled in an ice-salt mixture. The funnel should be surrounded by a freezing mixture.

Dissolve the precipitate from the filter paper with hot chloroform, and catch the solution in a weighed 100 to 150-cc. beaker. Wash the flask with hot chloroform which is added to the same beaker, in order to include any insoluble matter adhering to the walls of the flask. Evaporate off the solvent, dry to constant weight at 70° C., cool, and weigh.

$$\text{Percentage of hydrocarbons } A = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

HYDROCARBONS *B*

Hydrocarbons B.

44. Evaporate the alcohol from the flask containing the alcohol soluble unsaponifiable material, add 25 cc. of carbon tetrachloride, and transfer to a separatory funnel. Shake with concentrated H_2SO_4, drain off the discolored acid, and repeat with fresh portions of acid until there is no longer any discoloration. After drawing off all the acid, wash the carbon tetrachloride solution with repeated portions of water until all traces of acid are removed. Transfer the carbon tetrachloride solution to a weighed flask, evaporate off the solvent, and dry to constant weight at 70° C., cool, and weigh.

$$\text{Percentage of hydrocarbons } B = \frac{\text{Wt. of extract}}{\text{Wt. of sample}} \times 100$$

RUBBER HYDROCARBONS

(JOINT RUBBER INSULATION COMMITTEE)

Joint Rubber Insulation Committee Procedure.

45. Add to the flask containing the rubber residue from the alcoholic-potash extraction sufficient water to make the total 125 cc. and then add 25 cc. of concentrated HCl. Heat for 1 hour at 100° C. Decant the supernatant liquid through a hardened filter paper on a Büchner funnel, 7 cm. in diameter, using suction. Wash the residue with 25 cc. of hot water and decant. (Although a Büchner funnel is recommended, it is permissible to use an 11-cm. hardened filter paper with platinum cone in a 60-deg. funnel.) Perform this entire

treatment with water and HCl three times. The rubber at this stage should be white and practically free from black specks of undissolved fillers; if not, continue the acid treatment until the black specks disappear. (If carbon is present, all the particles of rubber will be grayish, bluish, or black, depending on the form and quantity of carbon used. Black specks in light particles of rubber usually indicate the presence of lead sulfide which must be removed to prevent the formation of lead sulfate on igniting the residue *C*.) Add 150 cc. of hot water to the flask and allow to stand on a steam bath or hot plate for 30 minutes and decant through the filter paper, repeating until washings are free from chlorides. Transfer all the rubber in the flask to the filter paper and dry as much as possible by suction. Wash the rubber with 50 cc. of alcohol (95-per-cent), using suction. Transfer the entire residue to a weighing bottle. Dry at 95 to 100° C. for 1 hour, cool in a vacuum desiccator under reduced pressure and weigh. Dry for 30 minutes, cool, and weigh, repeating this process until either constant weight is reached or the weight starts to increase. Let this weight be represented by *C*. The weight originally taken for the acetone extract determination shall be called *A*. Determine the ash (*E*) on a portion (*D*) of this residue (*C*), and sulfur (*H*) on the remaining portion (*G*). Also determine the sulfur (*F*) on the ash (*E*). Perform the ash determination as described in Section 35, and the sulfur determination as described in Section 33.

$$\text{Percentage of rubber hydrocarbons} = 100\,\frac{C}{A}\left(1 - \frac{H}{G} - \frac{E - F}{D}\right)$$

CELLULOSE

Cellulose. 46. (*a*) Treat 0.5 g. of rubber previously extracted with a constant boiling mixture of acetone and chloroform with 25 cc. of rubber solvent oil (see Section 18 (*h*)), in a 250-cc. lipped assay flask. Place in an air bath at a temperature of 145 to 150° C. until small particles can be seen distinctly in the supernatant liquid, which requires about 3 hours. Dilute with 15 cc. of benzene and 200 cc. of petroleum ether. Filter through a Gooch crucible and wash the residue thoroughly with warm acetone. Treat repeatedly with hot HCl (10-per-cent) until the residue is free from acid-soluble fillers. Wash the pad well with boiling water, and run small portions of acetone through it until the filtrate is colorless. Wash with alcohol and dry at 105° C. to constant weight. Remove the pad from the crucible with the help of a pair of sharp-pointed tweezers, using the under portion of the pad as a swab to clean the sides of the crucible, and place all of this material in a tared weighing bottle. Replace in the drying oven for about 10 minutes, cool and weigh.

Weight of weighing bottle, pad, insoluble fillers, and cellulose minus weight of the weighing bottle equals weight of pad, insoluble fillers, and cellulose.

(*b*) Transfer the contents of the weighing bottle to a 50-cc. beaker and pour over it 15 cc. of acetic anhydride and 0.5 cc. of concentrated HS_2O_4, and allow to digest for at least 1 hour, on the steam bath. After the mixture has cooled thoroughly, dilute with 25 cc. of acetic acid (90-per-cent), and filter through a weighed Gooch crucible. To guard against traces of the material being carried through, this filtration, as well as the ones to follow, must be very slow and only gentle suction can be used. Wash with hot acetic acid (90-per-cent), until the filtrate comes through absolutely colorless and then wash about four times more. Wash with acetone about five times. After having taken care that all of the material has been washed out of the beaker in which the acetylation took place, remove the crucible from the funnel, clean the outside thoroughly, and dry for 2 hours at 150° C. Cool and weigh. The original weight of the crucible plus weight of pad, fillers, and cellulose minus the weight of the crucible after acetylation equals cellulose.

$$\text{Percentage of cellulose} = \frac{\text{Cellulose}}{\text{Wt. of sample}} \times 100$$

BARIUM CARBONATE

Barium Carbonate.

47. Bartyes was determined by the calculation to barytes of all barium found in the sample. Obviously, if barium carbonate is present, it must be determined in order that an undue correction will not be made. The determination is as follows: A 1-g. sample, in a porcelain boat, is placed in a combustion tube through which passes a current of carbon dioxide. The sample is ashed in the tube. After ignition and cooling, in the atmosphere of carbon dioxide, the boat is removed, the residue finely ground in an agate mortar, transferred to a 250-cc. beaker, and treated with 5 to 10 g. of ammonium carbonate, 15 to 20 cc. of strong ammonia water, and about 50 cc. of distilled water. The mixture is boiled for 20 minutes, filtered, and the precipitate thoroughly washed to remove all soluble sulfates. The residue on the filter paper is washed back into the original beaker and about 10 cc. of glacial acetic acid with sufficient water to make the total volume about 100 cc. is added. This is heated to boiling and filtered through the same paper as before. Hydrogen sulfide is passed into

the filtrate to precipitate the lead and the solution is subsequently treated as in the determination of barytes. The final weight of barium sulfate obtained is calculated to barium carbonate.

$$\text{Percentage of sulfur required to convert barium present as carbonate to sulfate} = \frac{\text{Wt. of BaSO}_4 \times 0.1373}{\text{Wt. of sample}} \times 100$$

The Rubber Solvent Method described in Sections 57 to 60, inclusive, has been found to be more rapid in the determination of barium carbonate, and as accurate as the above method.

CALCULATIONS

Acetone Extract. 48. Percentage of acetone extract corrected, equals percentage of acetone extract, uncorrected, minus percentage of free sulfur, and percentage of waxy hydrocarbons. The percentage of waxy hydrocarbons equals percentage of hydrocarbons *A* plus percentage of hydrocarbons *B*.

Glue. 49. Multiply the percentage of rubber as compounded by 0.004 and 6.5 and call this value *A*. Subtract *A* from the percentage of glue and call this value *B*. Substitute *B* for glue in calculating the percentage of rubber hydrocarbons and then complete the calculations.

Sulfur as Antimony Trisulfide. 50. Percentage of sulfur as antimony trisulfide equals percentage of total antimony multiplied by $\frac{S_3}{Sb_2}$ equals percentage of total antimony multiplied by 0.400.

Antimony as Trisulfide. 51. Percentage of total antimony as trisulfide equals percentage of total antimony multiplied by $\frac{Sb_2S_3}{Sb_2}$ equals percentage of total antimony multiplied by 1.400.

Total Sulfur, Corrected. 52. Percentage of total sulfur corrected equals percentage of total sulfur minus percentage of sulfur as barium sulfate minus percentage of sulfur as antimony trisulfide. When barium carbonate is found, the percentage of sulfur necessary to convert it to sulfate must be added to the total sulfur, corrected.

Ash Corrected. 53. Percentage of ash corrected equals percentage of ash minus percentage of sulfur in ash plus percentage of sulfur as barium sulfate minus percentage of antimony in ash, calculated to Sb_2O_4.

Rubber Hydrocarbon. 54. Percentage of rubber hydrocarbon equals 100 minus the sum of the following percentages, except when it is determined by the Joint Rubber Insulation Committee's Procedure:

Acetone extract, corrected.
Chloroform extract.
Alcoholic-potash extract.
Total sulfur, corrected.
Ash, corrected.
Carbon.
Glue.
Total antimony as trisulfide.

55. The percentage of rubber hydrocarbon plus 5 per cent of its weight is taken as "rubber as compounded," except when the sum of the percentages of the acetone extract corrected, chloroform extract, and alcoholic-potash extract is less than the figure represented by the arbitrary 5 per cent, as in many high-grade compounds. Percentage of rubber as compounded is then equal to the percentage of rubber hydrocarbon plus the sum of the percentages of the acetone extract corrected, the chloroform extract, and the alcoholic-potash extract. **Rubber as Compounded.**

$$\text{Percentage of rubber by volume} = \frac{\text{Percentage of rubber as compounded} \times \text{sp. gr. of compound}}{0.94 \text{ (taken as the average sp. gr. of rubber)}}$$

$$\text{Ratio of acetone extract corrected} = \frac{\text{Percentage of acetone extract corrected}}{\text{Percentage of rubber as compounded}} \times 100$$

$$\text{Ratio of sulfur to rubber} = \frac{\text{Percentage of total sulfur, corrected}}{\text{Percentage of rubber as compounded}} \times 100$$

REPORT

56. The report shall include the following: **Report.**

(*a*) Percentage of acetone extract, corrected;
(*b*) Percentage of waxy hydrocarbons;
(*c*) Percentage of chloroform extract;
(*d*) Percentage of alcoholic-potash extract;
(*e*) Percentage of free sulfur;
(*f*) Percentage of total sulfur, corrected;
(*g*) Percentage of ash, corrected;
(*h*) Percentage of cellulose;
(*i*) Percentage of sulfur as barium sulfate;
(*j*) Percentage of total antimony;
(*k*) Percentage of sulfur as antimony trisulfide;
(*l*) Percentage of carbon;
(*m*) Percentage of glue;
(*n*) Percentage of rubber hydrocarbon;
(*o*) Percentage of rubber, as compounded;
(*p*) Percentage of rubber by volume;
(*q*) Ratio of acetone extract to rubber as compounded;
(*r*) Ratio of sulfur to rubber as compounded;
(*s*) Specific gravity.

RUBBER SOLVENT METHOD

57. Weigh two portions "*a*" and "*b*" of from 0.5 to 1 g. each of the finely-ground sample. Extract with a mixture of 32 per cent of **Rubber Solvent Method.**

acetone and 68 per cent of chloroform by volume for a minimum of 8 hours.[1] If the liquid in the extraction apparatus is still colored at the end of this time, the extraction should be continued. Remove the samples and put each into a 150-cc. lipped assay flask, add 20 to 25 cc. of the oil, cover with a watch glass and heat in an air bath at a temperature of 150 to 155° C. until solution appears complete and then 15 to 30 minutes more. Solution may be considered complete when the rubber colloid has been broken down and the oil seems quite clear. Remove the flasks from the air bath, cool to about 110° C., and add in a small stream 10 to 15 cc. of benzene, while mixing thoroughly; allow to cool and then dilute with sufficient petroleum ether to fill each flask to within about 2 cm. of the top. Mix thoroughly, cover the flasks to prevent evaporation and allow the mixture to stand overnight.

A. *Treatment of Portion "a."*

Procedure for Portion "a."

58. (*a*) Prepare a Gooch crucible with finely divided asbestos that has been previously treated with strong caustic soda solution and concentrated HCl and washed well with water. Ignite the crucible, cool and weigh; call this weight *c*. Filter the mixture by decantation through the crucible, using suction; wash well with petroleum ether, followed by warm acetone, and by a warm mixture of equal volumes of acetone and chloroform if the filtrate is dark. Remove as much as possible of the organic residue by washing; finally, wash with hot alcohol. A portion of the fillers will remain in the flask. Dry the crucible and flask with their contents for 1 hour at a temperature of 105 to 110° C. Cool and weigh. Call the weight of the flask and contents *d* and the weight of the crucible and contents *e*.

(*b*) Remove the acid-soluble compounding ingredients from the flask and Gooch crucible, collecting the solution in a 400-cc. beaker, by adding to the flask and crucible a few cubic centimeters of boiling alcohol. Allow to soak for 2 or 3 minutes and then wash two or three times with boiling water; let the flask cool, add 10 cc. of concentrated HCl and swirl the flask to bring the acid in contact with the compounding ingredients. Pour the acid from the flask into the crucible and let it stand until no more bubbles rise through the liquid. If carbonates are present, there is danger of loss by excessive frothing. This can be prevented by first adding a few drops of the acid to the crucible and sucking it through the pad. After the violent action has ceased, the remainder of the 10 cc. of acid is added. When no more gas is evolved, draw the acid through the pad and again wash with 20 cc. of acid, adding a little at a time. Wash well with hot water, and transfer as much as possible of the residue remaining in the flask to the asbestos pad. If by qualitative tests the sample was found to contain antimony, save the filtrate and washings for treatment as described in Paragraph (*c*). Dry the flask and crucible for 1 hour at 105 to 110° C., cool and weigh. Call the weight of the flask f, and that of the crucible containing the organic residue and acid-insoluble fillers, h. Burn the organic residue from the asbestos pad by igniting in a furnace at a temperature of 700° C., cool and weigh. Call this weight k. If the sample contains barytes, save the contents of the crucibles for treatment as described in Paragraph (*d*).

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[1] U. S. Bureau of Standards *Technologic Paper No. 162;* also *Rubber Age and Tire News*, pp. 445-447 (1920).

(*c*) *Determination of Sulfur Present as Antimony Trisulfide.*[1]—Dilute the filtrate in the beaker (see Paragraph (*b*)) to about 250 cc. and precipitate the antimony with H_2S. Filter off the antimony sulfide and wash the precipitate with H_2S water to which a little HCl has been added. Transfer the filter paper containing the antimony precipitate to a Kjeldahl flask, and add 12 cc. of concentrated H_2SO_4 and 5 g. of potassium sulfate. Heat the solution gently until it is colorless, dilute to 100 cc. and add 1 to 2 g. of sodium sulfite. Boil until the sulfur dioxide is driven out. Dilute to 250 to 275 cc., cool to 10 to 15° C., and titrate with standard permanganate solution. Calculate the antimony present to antimony trisulfide and express the sulfur present as antimony trisulfide in percentage of the sample and call this L.

(*d*) *Determination of Barytes.*—Transfer the contents of the crucible (see Paragraph (*c*)) to a 50-cc. porcelain crucible and fuse with 5 g. of a mixture of equal weights of sodium carbonate and nitrate. Stir well during the fusion. Cool the crucible, put it into a 250-cc. beaker, cover with distilled water and heat on the steam bath until all the solid material has been loosened from the crucible. Filter and wash the residue with warm water to free from sulfate. Wash the residue back into the beaker and dissolve in HCl (10-per-cent), using about 10 cc. excess and keeping the solution warm. Filter off the asbestos, wash well with hot water, and precipitate the barium in the solution with 10 cc. of H_2SO_4 (10-per-cent). Heat on the steam bath, filter off the precipitate, ignite and weigh the barium sulfate.

$$\text{Percentage of sulfur present as barytes} = m = \frac{100 \times \text{wt. of BaSO}_4 \times 0.1373}{\text{Wt. of sample "}a\text{"}}$$

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[1] S. Collier, M. Levin, and J. A. Scherrer, "Determination of Antimony in Rubber Goods," *India Rubber World*, Vol. 64, p. 580 (1921).

B. Treatment of Portion "b" for Sulfur in Compounding Ingredients:

Procedure for Portion "b."

59. Treat portion "*b*" as described in Section 58(*a*), but omit the weighing of the crucible. After the pad has been dried, transfer it to the flask. The last traces of the fillers can be removed from the sides of the crucible with wads of absorbent cotton moistened with a little warm water. Add to the fillers about 10 cc. of bromine water, and swirl the flask to moisten the contents. Add 20 cc. of concentrated HNO_3 saturated with bromine. Allow to stand for 15 minutes and then heat on the steam bath for 1 hour. Transfer the contents of the flask to a 75-cc. crucible and evaporate to dryness. Complete the determination of sulfur by the method described in Section 33. Let the value for the percentage of sulfur in compounding ingredients be represented by *n*.

Calculations.

60. (*a*) *Calculations.*—The percentage of total inorganic compounding ingredients, corrected, equals:

$$\frac{100\,(e + d + k) - (c + f + h)}{0.5} + (m + L) - n$$

(*b*) To determine the percentage of rubber hydrocarbon subtract from 100 the sum of the percentages of acetone, chloroform, and alcoholic potash extracts, free carbon, glue, total sulfur corrected, and total inorganic compounding ingredients corrected.

TENTATIVE METHOD OF TEST
FOR
HARDNESS OF RUBBER[1]

A.S.T.M. Designation: D 314 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1929; REVISED, 1931.[2]

Scope. 1. This method of test is intended for the more common grade of rubber such as tire treads, most automotive mechanical rubber parts, etc., but not for extremely hard or extremely soft rubbers which fall beyond the range of the instrument specified.

Hardness of Rubber. 2. For the purpose of this test, the hardness of rubber shall be considered as that property by virtue of which the surface and adjoining layers resist indentation when subjected to a definite pressure by an indentation element of standard size, the contact surface of which conforms in shape to a portion of a true spherical surface.

A.S.T.M. Hardness Number. 3. The A.S.T.M. Hardness Number is the indentation in thousandths of an inch determined under definitely prescribed conditions.

APPARATUS

Apparatus. 4. The apparatus shall consist of a table for supporting the sample, an indentor acting under a dead-weight load, an annular pressure foot exerting a definite force on the surface of the sample surrounding the indentation area and a suitable device for indicating depth of indentation.

Table. 5. The table used to support the test piece shall possess a flat horizontal surface of minimum linear dimension of 2 in.

Indentor. 6. (*a*) The indentor shall consist of a rigid vertical shaft, the lower end of which is finished to a true hemisphere $\frac{3}{32}$ in. ± 0.0005 in. in diameter. The maximum diameter of that portion of the shaft passing through the pressure foot described in Section 7 shall not exceed that of the indentor point. The point shall be made of a highly-polished non-corrosive, hard metal properly treated to resist wear due to continuous use (a plated point is not satisfactory).

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] Revision approved by Committee E-10 on Standards, February 20, 1931.

(*b*) The indentor shall be actuated by a freely acting dead-weight load of 3 lb. ± 0.25 oz. Less than 0.25 oz. shall be required to overcome friction and to produce perceptible motion of the penetrator when counter-balanced.

(*c*) The indentor shall act through the opening in the center of the pressure foot.

Pressure Foot. 7. (*a*) The pressure foot shall be $\frac{5}{8}$ in. ± 0.0005 in. in diameter and shall have a hole $\frac{7}{64}$ in. ± 0.005 in. in diameter located at the center. It shall be sufficiently thick to insure rigidity and the edges shall be rounded off with a radius of $\frac{1}{64}$ in. The inner surface of the pressure foot shall be parallel to and concentric with the surface of the shaft of the indentor. The contact surface of the pressure foot shall be at right angles to the inner surface, and shall be parallel to the table which supports the test specimen.

(*b*) The pressure foot shall be subjected to a freely acting load of 5 lb. ± 0.75 oz.

Indentation Dial. 8. Vertical movement of the indentor shall actuate a suitable dial gage graduated to show indentation in 0.001 in. The accuracy over the whole range shall be within ±0.0005 in. indentation. The gage shall be mounted so as to be rigid with the pressure foot. The indentation measured during the test will therefore be the distance between the contact surface of the pressure foot and the tip of the ball point of the indentor.

PROCEDURE

Hardness Testing Standard:

Test Specimen. 9. When the instrument is used as a reference standard for the calibration of other types of hardness instruments or in arbitration tests, uniform test specimens at least $\frac{1}{2}$ in. in thickness with parallel sides (slab form) shall be employed. The minimum lateral dimension of the specimen shall be 2 in.

Procedure. 10. (*a*) *Method.*—The pressure foot and indentor shall be lowered until contact is made with the test specimen. The points of indentation shall be at a minimum distance of $\frac{1}{2}$ in. from the edge of the test specimen. The full load shall then be allowed to act immediately, without shock, on the indentor. Readings on the indentation dial shall be made exactly 30 seconds after the full load is applied.

(*b*) *Number of Readings.*—The test specimen shall be shifted to a new position after each contact in order to avoid errors due to fatigue effects. A minimum of five readings shall be made and their average taken as the hardness measurement excepting that no reading may differ by more than ± 0.002 in. from the mean value. Any readings known to be definitely in error shall be discarded.

(*c*) *Temperature.*—All tests to be truly comparative should be conducted at the same standard temperature which shall be recorded in every case. Test specimens shall be subjected to the standard test temperature a sufficient period of time prior to testing to insure temperature equilibrium as may be shown by constant indentation values.

(*d*) *A.S.T.M. Hardness Number.*—The average indentation value determined in accordance with Paragraphs (*a*) and (*b*) shall be expressed as a whole number, signifying thousandths of an inch indentation, and reported as the A.S.T.M. hardness number of the sample.

Routine Testing:

Test Specimen. 11. When the instrument is used for routine testing, satisfactory results may be secured by using specimens having dimensions other than those required in the procedure for standard tests, Section 8. In all cases the specimens tested shall for comparison be of essentially the same thickness and size. These results will be comparative only.

Procedure. 12. (*a*) *Method.*—The hardness shall be determined in accordance with Section 10 (*a*).

(*b*) *Number of Readings.*—A sufficient number of readings shall be taken to provide indentation values checking with ± 0.002 in.

TENTATIVE SPECIFICATIONS

FOR

TOLERANCES AND TEST METHODS FOR RAYON[1]

A.S.T.M. Designation: D 258 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1926; REVISED, 1927, 1931.

DEFINITIONS

Definitions.

1. (*a*) *Rayon* (formerly known as artificial silk).—A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament, or filaments, by means of some precipitating medium.

(*b*) *Rayon Yarns.*—Yarn composed of more than one continuous rayon filament.

(*c*) *Spun Rayon.*—Yarn made from cut rayon filaments, the cut filaments being twisted and drawn out into a yarn by usual spinning processes.

Classification.

2. (*a*) *Nitro-Cellulose Rayon* (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

(*b*) *Viscose Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose xanthate.

(*c*) *Cuprammonium Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

(*d*) *Cellulose-Acetate Rayon.*—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

IDENTIFICATION

Identification Methods.

3. Any rayon tested by these methods shall be in the bleached or unbleached state and shall be free from oil or other foreign substances.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

A suggested procedure for removing the oil or other foreign substances is to rinse the rayon in (*a*) boiling water, (*b*) denatured alcohol, and (*c*) ethyl ether, then allow to dry at room temperature.

TO DISTINGUISH CELLULOSE-ACETATE FROM ALL OTHER RAYONS

4. Cellulose acetate rayon is distinguished from the regenerated cellulose rayons by its solubility in pure acetone or in glacial acetic acid, if acetone is not available. A small sample of cellulose acetate rayon will dissolve completely in a few minutes; the cellulose rayons are insoluble. The result of this test can be confirmed by twisting the fibers to a tight wad and cautiously applying the flame of a lighted match. Cellulose acetate rayon fuses and burns and hardens at once into a brittle substance, globular in appearance.

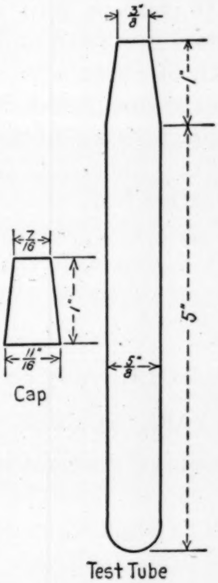

FIG. 1.—Special Test Tube With Cap.

TO DISTINGUISH NITRO-CELLULOSE RAYON FROM VISCOSE AND CUPRAMMONIUM RAYONS

5. If the rayon is not cellulose acetate, moisten it with a 1-percent solution of diphenylamine in a mixture of two parts of concentrated sulfuric acid and one part of glacial acetic acid. (This mixture of acids is recommended instead of sulfuric acid alone as it does not dissolve rayon so quickly and the color persists longer.) Nitro-cellulose rayon assumes a deep blue color immediately and the fibers

dissolve rapidly to a blue solution. Viscose and cuprammonium rayons are not colored blue and dissolve more slowly.

TO DISTINGUISH VISCOSE RAYON FROM CUPRAMMONIUM RAYON

6. If the rayon is neither cellulose acetate nor nitro-cellulose rayon, test it for sulfide sulfur. A special test tube with cap of the construction shown in Fig. 1 is convenient for this test in order to protect the test paper from contamination by sulfide in the air.

Introduce 0.5 g. of the rayon into the test tube and add 10 ml. of a 3-per-cent sulfuric acid solution. Place a piece of filter paper, previously soaked in a 10-per-cent lead acetate solution, over the opening of the tube and hold it in position by means of the cap. Immerse the tube to a depth of about 4 in. in a steam bath and heat for 4 hours. If at the end of this period the exposed part of the lead acetate paper becomes stained with a brown or black color (indicating the presence of sulfide sulfur), the sample is viscose rayon. Cuprammonium rayon gives a negative test.

NOTE.—In the opinion of the committee, (1) none of the staining methods thus far proposed can be invariably depended upon to distinguish between viscose and cuprammonium rayon, and (2) no thoroughly reliable method of identifying cuprammonium yarn has been discovered.

TOLERANCES

SIZE OR YARN NUMBER (DENIER)

Size of Rayon Yarn.

7. The denier of a yarn is the weight in grams of 9000 meters.

8. (*a*) The average size or denier of each skein, tube, spool, cop, pirn or cone of rayon as supplied by the seller either bleached or unbleached, as found by test, shall not vary above or below the specified size or denier more than:

10 per cent for sizes finer than 150 denier, and
8 per cent for 150 denier or coarser.

(*b*) The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of rayon yarn in the singles, either bleached or unbleached, as found by test shall not vary above or below the specified size more than:

5 per cent for sizes finer than 150 denier, and
4 per cent for 150 denier or coarser.

Size of Spun Rayon Yarn.

9. The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of spun rayon yarn in the singles, either bleached or unbleached, as found by test, shall not vary more than 5 per cent above or below the specified size.

TWIST

Definition.

10. *Direction of Twist.*—The direction of twist shall be as defined in the Standard Definitions of Terms Relating to Textile Materials (A.S.T.M. Designation: D 123) of the American Society for Testing Materials, as follows:

Twist, Direction of.—In the case of yarn or cord, the yarn or cord has right-hand or regular twist if when it is held vertically the spirals or twists are seen to incline upward in a right-hand direction and has left-hand or reverse twist when the spirals or twists are seen to incline upward in a left-hand direction.

NOTE.—Attention is called to the fact that this definition of twist is opposite to that used in the silk trade.

Average Twist.

11. The average twist of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn shall not vary beyond the following specified limits:

TURNS PER INCH	ALLOWABLE VARIATIONS
Under 7½	± 25 per cent
7½ to 10	± 15 per cent
Over 10	± 5 per cent

STRENGTH

Tensile Strength.

12. (*a*) The average tensile strength of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn in the singles, or plied, either bleached or unbleached, as found by test, shall not be less than the specified strength.

(*b*) Ultimate strength, or strength at the highest yield point, may be specified.

METHODS OF TESTING

SIZE OR YARN NUMBER (DENIER)

(*A*) *Preferred Method*

Size, Preferred Method.

13. The number or denier shall be determined (except when the rayon is on beams) from skeins which have been prepared, reeled, and weighed under prevailing atmospheric conditions from the spools, cops, tubes, cones, skeins, or other packages.

Test Skein.

14. Any reel employing a straight wind traverse having a perimeter of 112.5 cm. may be used. (See Note.) For yarns in skein form, a speed of 100 to 150 r. p. m. shall be used. For yarns on spools, cops, tubes or cones, the yarn shall be drawn off over end and a speed of 200 to 300 r. p. m. of the reel shall be used. The tension on the yarn

shall not be heavier than is necessary to lay the yarn smoothly on the reel at the specified speed. The skeins shall be weighed separately on a balance which shall be accurate to 0.25 per cent of the average weight of one skein.

Note.—In a laboratory which is equipped for testing cotton yarns only, the skeins may be prepared on any reel having a perimeter of $1\frac{1}{2}$ yd. Each skein must contain 200 ends as before.

If a skein of this length is used the yarn number or denier shall be calculated from the following formulas:

If the weighing is made in grams.—

$$\text{Yarn number or denier} = \frac{\text{Weight of 300-yd. skein in grams} \times 1.64}{0.05 \text{ gram (per denier)}}$$

If the skeins are weighed in grains.—

$$\text{Yarn number or denier} = \frac{\text{Weight of 300-yd. skein in grains} \times 1.64}{0.7716 \text{ grain (per denier)}}$$

Number of Tests. 15. Two skeins of 200 turns each from each of 10 spools, cops, tubes, cones or skeins, from one case out of every 10 cases shall be made, and the average of these 20 tests shall be the size or denier.

16. Rayon received on beams shall be tested as specified.

Weight Correction. 17. The weight of each skein shall be reduced to a common basis of standard moisture regain for the class of rayon under test by the following formulas:

(*a*) For nitro-cellulose, viscose and cuprammonium rayons:

$$\text{Weight, corrected to 11 per cent moisture regain} = \frac{\text{Actual skein weight} \times 111}{100 + \text{actual percentage of regain}}$$

(*b*) For cellulose acetate rayons:

$$\text{Weight, corrected to 6.5 per cent moisture regain} = \frac{\text{Actual skein weight} \times 106.5}{100 + \text{actual percentage of regain}}$$

Regain in Sizing Skeins. 18. To determine the actual percentage of moisture regain present in the sizing skeins, two groups of three skeins each shall be taken immediately after weighing and the weight of each group recorded. They shall then be placed in two separate baskets in a conditioning oven and dried to constant weight on a balance sensitive to 0.25 per cent of the average weight of one skein at 105 to 110° C. (221 to 230° F.). The moisture regain of each group shall then be computed as the percentage of the dry weight and the average of these two shall be the actual percentage of moisture regain in the sizing skeins.

Calculation. 19. The size or yarn number in denier is calculated as follows:

$$\text{Denier size or yarn number} = \text{Corrected weight of 225-meter skein in grams} \times 40$$

20. The yardage per pound of rayon of any given denier may be calculated by the following formula:

$$\text{Yards per pound of rayon} = \frac{4,464,528}{\text{Given denier}} \text{ (yards per pound of one denier yarn)}$$

(*B*) *Alternate Method*

Size, Alternate Method. 21. The winding of the skeins shall be done under prevailing atmospheric conditions following the procedure outlined in Sections 13 to 15 and these test skeins shall be conditioned for at least three hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity at 70° F. (21° C.) and then weighed in this atmosphere.

22. The size or yarn number in denier shall be calculated from the following formula:

$$\text{Size or yarn number} = \text{weight of 225 meter skein in grams} \times 40$$

STRENGTH

(*A*) *Preferred Method*

Test Skeins. 23. One skein from each of the ten spools, cops, tubes, cones or skeins drawn for a sample shall be prepared as described in Sections 14 and 15. The number of turns in these strength skeins shall be as specified in Table I. For sizes which require 200 ends, ten of the sizing skeins may be used if desired.

TABLE I

DENIER OF RAYON		NO. OF TURNS IN STRENGTH SKEIN
1 - 50	denier	400
51 - 75	"	200
76 - 120	"	150
121 - 200	"	100
Over 200	"	50

Conditioning. 24. After conditioning for at least three hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.) these ten skeins shall be separately broken on an automatic power yarn tester of inclination balance type of 25 kg. (55 lb.) or 50 kg. (110 lb.) capacities. The lower capacity shall be used until the swing of the pendulum exceeds an angle of 45 deg. from the vertical. When yarns break above this mark the higher capacity of testing machine shall be used.

Apparatus.

25. The machine shall be equipped with an automatic charting device to record stretch at any load.

26. Any tendency to friction, backlash, or play in the recording device, lower jaw, or screw, shall be overcome as far as practicable by counter balancing.

Jaws.

27. Clamps for holding the 200-end test skein shall consist of flat metallic jaws. These shall be covered with one layer of rubber tire tape which shall press directly against the specimen. One gripping surface shall be hinged or swiveled and the other shall be rigidly connected to the frame of the jaw. The pressure between the jaws shall be secured by any suitable mechanical device so constructed as to grip the yarns firmly before the testing load is applied and prevent visible slipping during the progress of the test.

Procedure.

28. The initial distance between jaws shall be 10 cm. (4 in.). The skein to be tested shall first be clamped in the upper jaws, spread out evenly so that the ends are parallel, forming a ribbon approximately $\frac{3}{8}$ to $\frac{3}{4}$ in. in width. The rayon shall then be drawn down through the lower jaws and spread out to make a band of equal width, pulled just taut and clamped.

Speed of Jaw.

29. The pulling jaw shall travel at a speed of 6 in. per minute.

One test shall be made on each of the 10 skeins prepared as in Section 23 and the average of these 10 tests shall be the strength.

(*B*) *Alternate Method*

Procedure, Alternate Method.

30. Five single strands from each of 10 spools, cops, tubes, cones, or skeins, shall be broken after conditioning the skeins for three hours and any other form of package for 12 hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.). A single strand tester of proper capacity with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per minute shall be used.

Strength.

31. The average of 50 tests shall be the tensile strength.

TWIST

Twist.

32. The twist shall be determined on any standard twist tester with jaws set 10 in. apart. The yarn shall be clamped in the jaws under a definite tension by attaching weights. The tension to be used shall approximate a value to be determined by the following formula:

$$\text{Tension in grams} = \frac{\text{Specified denier}}{30}$$

Example.—The weight for 150 denier rayon would be $\frac{150}{30} = 5$ g.

33. Two tests, from each of five spools, cops, tubes, cones or skeins, shall be made and the average of these ten tests calculated to turns per inch shall be the twist. **Calculation.**

MOISTURE REGAIN

34. The standard moisture regain of nitro-cellulose, viscose and cuprammonium rayons shall be 11 per cent of the dry weight. **Moisture Regain.**

35. The standard moisture regain of cellulose-acetate rayons shall be 6.5 per cent of the dry weight.

TENTATIVE SPECIFICATIONS AND TEST METHODS

FOR

COTTON GOODS FOR RUBBER AND PYROXYLIN COATING[1]

A.S.T.M. Designation: D 334 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Quality. 1. The goods shall be made of cotton thoroughly cleaned and carded, free from waste, and shall be of good commercial quality, evenly woven.

Defects. 2. Cotton goods purchased under these specifications will be used in the manufacture of coated fabrics and the vendor, in the manufacture and inspection of these goods, shall endeavor to meet the requirements of this industry. All fabrics shall be inspected and burled on both sides. Certain defects shall be classed as major defects and shall not occur in a roll on an average of more than one defect to every fifteen yards. A minimum allowance of $\frac{1}{4}$ yd. will be made for each major defect. The following defects are classified as major defects:

Smash
Washed out oil spots
Starchy places
Group float
Heavy filling
Shuttle mark
Heavy warp
Kinky filling
Two contiguous filling threads missing

NOTE.—These defects are probably not all which should be listed so that this list is subject to change by common agreement. Also, one major defect on the average of every 15 yd. does not represent the quality desired but has been suggested as a fair basis both to mill and to consumer. The aim of the mills will be so to improve their quality that this average yardage between defects may be increased.

The following shall not be present in goods furnished under these specifications:

Oil spots
Holes
Torn selvage
Warp streaks

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

These specifications conform in substance but not in form with the Commercial Standard Specifications for Cotton Cloth for Rubber and Pyroxylin Coating (CS 32-31) of the U. S. Department of Commerce.

SELVAGE

3. Selvages of these fabrics shall be of uniform width and of equal width on both edges of the fabric. Selvages shall be so made that the tension shall be the same as and shall lie flat with the body of the cloth. Baggy goods and curling selvages shall be cause for rejection. **Selvage.**

SIZING

4. As little sizing shall be used in the fabric as is necessary for its proper manufacture. Assuming an average content of natural oils and waxes indigent to the cotton of 3.2 per cent, the total percentage of sizing and natural oils and waxes shall not exceed that given below for each type of fabric: **Sizing.**

Sheetings	8.5 per cent
Drills	11 per cent
Sateens	10.25 per cent
Broken Twills	8.15 per cent

INJURIOUS CHEMICALS

5. It shall be recognized that there are certain chemicals, listed below, which are injurious to rubber, and in so far as these come under the control of the mill the quantity shall not exceed the following percentage: **Injurious Chemicals.**

Copper	0.001 per cent
Manganese	0.0005 per cent
Grease	1 per cent

WIDTH

6. The width of the fabric as determined by test shall not vary more than ± 1.5 per cent from the specified width. **Width.**

COUNT

7. The count shall be as specified for the fabric in question with a tolerance of ± 2 per cent in the warp and ± 5 per cent in the filling on the specified count. The average of the readings in a shipment shall show a variation of not over 1 per cent in the warp and 3 per cent in the filling. **Count.**

UNIT WEIGHT

8. The unit weight shall be as specified for the fabric in question with a minus tolerance of 1 per cent on a shipment, 2.5 per cent on a roll and 5 per cent on a piece, from the specified width. **Unit Weight.**

TENSILE STRENGTH

Tensile Strength.

9. (*a*) The specified tensile strength shall conform to the following requirements. In the case of constructions not pro rata to any of those listed below, any specified strength shall be agreed upon when the contract is placed and based on the following tensile strengths:

Construction, Including Pro Ratas			Tensile Strength, minimum, lb.	
			Warp	Filling
66 in. 48/48	3.00 yd.	Sheeting	35	25
63 in. "	3.14 "	"	35	25
60 in. "	3.30 "	"	35	25
57 in. "	3.47 "	"	35	25
52 in. "	3.85 "	"	35	25
50 in. "	4.00 "	"	35	25
49 in. "	4.05 "	"	35	25
48 in. "	4.17 "	"	35	25
59 in.	2.25 "	Drill	58	36
66/67 in.	1.87 "	"	60	40
65 in.	1.93 "	"	60	40
52 in.	2.38 "	"	60	40
49 in.	2.53 "	"	60	40
52 in.	2.20 "	"	62	48
59 in.	1.85 "	"	72	43
56 in.	1.93 "	"	72	43
54 in.	2.00 "	"	72	43
69 in.	1.37 "	Twill	80	59
59 in.	1.60 "	"	80	59
54 in. 85 sley	1.14 "	Broken Twill	95	110
56 in.	1.10 "	"	95	110
54 in. 76/52	1.14 "	"	100	100
56 in.	1.10 "	"	100	100
54 in. 85/64	0.98 "	"	110	130
56 in.	0.95 "	"	110	130
54 in. 96 sley	1.55 "	Sateen	110	50
54 in. 96 sley	1.30 "	"	110	75
53 in.	1.32 "	"	110	75
54 in. 96 sley	1.10 "	"	125	95
53 in.	1.12 "	"	125	95
54 in. 96 sley	1.05 "	"	125	120

(*b*) The average of five determinations in the direction of the warp and five in the direction of the filling shall be not less than the specified tensile strength for warp and filling respectively.

LENGTH OF CUTS

Length of Cuts.

10. Two classes of delivery in respect to length of piece may be specified in the purchase contract as follows:

(*1*) Double Cuts as Far as Practicable; and

(*2*) Long Cuts.

(*a*) *Sheetings.*—For sheetings in the classification known as "Double Cuts as Far as Practicable," 10 per cent of pieces in from 40 to 80-yd. lengths will be accepted at the contract price, the balance shall be in pieces not less than 80 yd. in length.

The designation of long cuts of sheetings shall require an average length of piece of 250 yd. with a minimum of 200 yd., the vendor having the privilege of including up to 10 per cent, if made, of pieces from 100 to 200 yd. in length at the contract price.

(*b*) *Drills.*—The designation of long cuts of drills shall require an average length of piece of 175 yd. with a minimum of 120 yd., the vendor having the privilege of including up to 10 per cent, if made, of pieces from 60 to 120 yd. in length at the contract price.

(*c*) *Sateens, Broken Twills, and Moleskins.*—The designation of long cuts of sateens, broken twills, and moleskins shall require a minimum length of 120, yd., the vendor having the privilege of including not more than one 60-yd. piece for each 500 yd. shipped at the contract price.

METHODS OF TESTING

TEST CONDITIONS

Test Conditions.

11. Tests shall be made at prevailing atmospheric conditions, except in the settlement of disputes regarding strength. In such cases, tests shall be made on material which first has been brought to standard moisture condition, obtained by exposure for four hours to an atmosphere having a relative humidity of 65 per cent at 70° F.

Number of Tests.

12. In the acceptance or rejection of each shipment, tests shall be made on samples taken from 20 per cent of the rolls in each shipment; except that in shipments of 1 to 3 rolls, each roll shall be tested; in shipments of 4 to 9 rolls, three rolls shall be tested; in shipments of 10 to 19 rolls, four rolls shall be tested. Five samples shall be taken from each roll selected for purposes of tests on the warp and for tests on the fillings. The vendor shall have an opportunity of checking the accuracy of the tests and if agreement cannot be reached, tests shall be made by a disinterested party whose decision shall be final.

STANDARD METHODS

Standard Methods.

13. All test procedure not covered in these specifications shall be in accordance with the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[1]

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[1] 1930 Book of A.S.T.M. Standards. Part II, p. 1102.

SIZING

Sizing. 14. Tests to determine the amount of sizing shall be made as follows:

(*a*) Cut one square foot of fabric and dry to a constant weight in a ventilated drying oven maintained at a temperature of 220 to 230° F. Weigh samples from time to time and when two such weighings not less than 10 minutes apart do not show a loss more than 0.1 per cent of the previous weight, the material is considered to be bone dry. These weights may be obtained in a conditioning or drying oven with a weighing device mounted on top in such a way that samples may be weighed while they are in the oven; or, if no such weighing device is available, the samples may be taken from the oven and very quickly inserted in a glass capsule or bottle with an air-tight glass stopper. The bottle, with the samples, may then be weighed and the tare weight of the bottle subtracted.

(*b*) Boil for 30 minutes in a 0.5-per-cent HCl solution; such solution to be boiling before the samples are placed in it.

(*c*) Remove samples and rinse thoroughly in clear water.

(*d*) Boil the samples for 30 minutes in a 1-per-cent solution of sodium carbonate; the solution to be boiling before the samples are placed in it.

(*e*) Remove samples and rinse thoroughly in clear water.

(*f*) Obtain bone-dry weight as described in Paragraph (*a*).

(*g*) *Calculation.*—Calculate the percentage loss in weight from the results obtained in Paragraphs (*a*) and (*f*) and subtract 3.2 per cent as an allowance for the extracted weight of oil, waxes and other foreign matters; the difference arrived at is considered to be the percentage of size.

NOTE.—In arriving at the average of 3.2 per cent, many tests were made in the following manner: by cutting 1 yd. of yarn from beam before it entered slasher and then cutting a 1-yd. sample of the sized yarn and also a 1-yd. sample of cloth from the loom, and boiling them in same process; the actual average obtained was 3.2 per cent, the minimum being 2.63 per cent and the maximum 3.85 per cent.

WIDTH

Width. 15. The width of the fabric in any roll or piece shall be determined by laying the fabric on a flat surface, under no tension, with wrinkles removed, and measuring the width perpendicular to the selvage, at five different places evenly distributed through the roll or piece. The average of these five measurements shall be considered the actual width.

COUNT

16. The count of the fabric in any roll or piece shall be determined by counting a space of not less than 1 in. in at least five different places in the roll or piece without duplicating the determination on any one set of threads. The average of these five or more determinations in the warp and filling shall be the count. No determination shall be taken nearer the selvage than one-tenth the width of the fabric. **Count.**

UNIT WEIGHT

17. The unit weight shall be expressed in linear yards of the fabric per pound and shall be determined from the invoiced yardage and the weight of the entire roll or piece (both verified when necessary). **Unit Weight.**

TENSILE STRENGTH

18. The tensile strength shall be determined by the 1 by 1 by 3-in. Grab Test in accordance with Sections 11 and 12 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials[1] shall conform to the following requirements: **Tensile Strength.**

The back half of each pair of jaws shall be 2 in. or more in width and the front half shall be 1 in. in width. The jaws shall be planed smooth and flat with edges slightly rounded to prevent cutting. The initial openings between jaws of the testing machine shall be 3 in. and the pulling jaws shall travel at a uniform rate of 12 in. per minute. Test pieces shall be 6 by 4 in. wide and no two test pieces shall include the same threads.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1102.

TENTATIVE SPECIFICATIONS
FOR
0.007-IN. COTTON TAPE[1]

A.S.T.M. Designation: D 335 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover 0.007 in. cotton tapes for use in the electrical industry.

MANUFACTURE

Cotton. 2. (*a*) Tapes shall be woven uniformly from a good grade of cotton. They shall, as far as practicable, be free from "motes" or other impurities found in improperly cleaned cotton.

(*b*) Tapes shall be woven with a selvage edge which shall be held as close as is commercially possible to the nominal thickness of the tape.

CHEMICAL PROPERTIES

Sizing. 3. (*a*) In order to process properly and give a smooth finish, manufacturers may use a small amount of sizing in the warp threads, but such sizing shall not exceed 8 per cent of the total weight.

(*b*) Finished tapes shall be practically neutral in reaction. Acids or alkalies shall not be present in quantities which will cause the tape to deteriorate or cause other harm when impregnated by the purchaser.

It is recommended that the pH value lie between 6.5 and 7.5 based on a neutrality point of 7.0.

PHYSICAL PROPERTIES

Physical Properties. 4. The tape shall conform to the following requirements subject to the tolerances specified in Sections 2 to 5 of the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (A.S.T.M. Designation: D 259) of the American Society for Testing Materials:[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1093.

WIDTH, IN.	ENDS, TOTAL	PICKS PER IN.	WEIGHT, MINIMUM, YD. PER LB.	TENSILE STRENGTH, MINIMUM, LB.[a]
½	30	30	350	20
½	36	36	250	30
¾	45	30	225	35
¾	56	36	175	40
1	60	30	160	40
1	72	36	130	50
1½	90	30	120	60
1½	108	36	75	75

[a] Values are average of five tests.

Methods of Testing. 5. All test procedures shall be conducted in accordance with Sections 6 to 19 of the Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (A.S.T.M. Designation: D 259) of the American Society for Testing Materials.[1]

PACKING, MARKING, AND SHIPPING

Winding. 6. (*a*) Tapes shall be wound tightly on a suitable bushing and well blocked to give smooth sides to the roll.

(*b*) Tapes shall be so rolled that the edges are not folded over.

(*c*) *Bushing.*—The bushing shall be flush with the edge of the tape and shall not vary from the nominal tape width by more than $\frac{1}{32}$ in. Bushings shall not be split and shall have sufficient strength to withstand damage in handling and transit. The inside diameter of bushings shall be ⅜ in.

Size of Rolls. 7. Tapes shall be put up in rolls containing approximately 36 yd. or 72 yd., as specified.

Splices. 8. (*a*) The number of splices in any package of ten 36-yd. rolls shall not exceed four. For larger packages or rolls this limit shall be pro-rated.

(*b*) All splices shall be sewed and shall be smooth and flat. Splices shall not exceed in thickness twice the thickness of the tape.

Securing Ends of Roll. 9. Pasters or starch paste may be used in securing the ends of rolls. Pins shall in no case be used.

Packing. 10. Tapes may be packed 10 or 20 rolls to a package.

Marking. 11. Packages shall be plainly and indelibly marked with the size of tape and number of rolls contained therein, the manufacturer's name, and the grade or trade mark.

Shipping. 12. (*a*) Packages of tape shall be shipped in suitable cases to prevent damage in transit and handling.

(*b*) Cases shall be plainly and indelibly marked with the purchaser's order number, the size of tape, and the number of gross yards contained therein.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1093.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR SILK AND COTTON TAPES[1]

A.S.T.M. Designation: D 259 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover the tolerances and test methods for silk and cotton tape.

TOLERANCES

THICKNESS

Thickness. 2. The thickness of the tape shall not vary from that specified by more than the following amounts:

THICKNESS, IN.	PERMISSIBLE VARIATIONS
Up to and including 0.007	±0.0008 in.
Over 0.007 and including 0.011	±0.001 in.
Over 0.011 and including 0.020	±0.0015 in.

WIDTH

Width. 3. The width of the tape shall not vary from that specified by more than the following amounts:

NOMINAL WIDTH OF FABRIC, IN.	PERMISSIBLE VARIATIONS
$\frac{1}{2}$	$\pm\frac{1}{32}$ in.
$\frac{3}{4}$	$\pm\frac{1}{32}$ in.
1	$\pm\frac{3}{64}$ in.
$1\frac{1}{4}$	$\pm\frac{3}{64}$ in.
$1\frac{1}{2}$	$\pm\frac{3}{64}$ in.
Above $1\frac{1}{2}$	$\pm\frac{1}{16}$ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

These specifications are in effect a tentative revision of, and will supersede when adopted as standard, the present Standard Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes (D 259 – 27), see 1930 Book of A.S.T.M. Standards, Part II, p. 1093.

WEIGHT

4. The average weight of the tape shall be calculated in yards per pound and in no case shall the yardage be less than that specified. **Weight.**

CONSTRUCTION

5. The total number of ends shall be not less than specified. The picks per inch shall not vary more than the following: **Construction.**

± 1 pick for tapes counting up to and including 48 per inch;

± 2 picks for tapes counting over 48 per inch.

METHODS OF TESTING

THICKNESS

6. The thickness of the tape shall be determined by a micrometer having measuring faces not less than $\frac{7}{16}$ in. nor more than $\frac{1}{2}$ in. in diameter. Readings shall be made while the micrometer faces hold the tape with just sufficient pressure to permit movement of the tape without distorting the threads. **Method of Measuring Thickness.**

7. At least ten measurements shall be taken on the samples used for weight determination (Section 10) and the average and range of thickness recorded. **Number of Measurements.**

WIDTH

8. The width of the tape shall be determined by the use of a standard steel scale graduated to read within the degree of accuracy specified for width tolerances in Section 3. The tape shall lay flat on a smooth surface at the time of measurement. **Method of Measuring Width.**

9. At least ten measurements shall be taken on the samples used for weight determination (Section 10) and the average and range of width recorded. **Number of Measurements.**

WEIGHT

10. The weight of the tape shall be determined by accurately measuring and weighing samples 2 yd. in length and then calculating the yards per pound. **Weight.**

11. Not less than three weight determinations shall be made per shipment, such determinations to be made on different rolls from different packages. The average of these three determinations shall indicate the average of the shipment involved. **Number of Tests.**

CONSTRUCTION

12. The total number of ends shall be determined irrespective of the width of the tape. **Ends.**

Picks. 13. The number of picks shall be determined in a length of 1 in.

Number of Tests. 14. The number of ends shall be taken as that secured by making one determination per sample. The number of picks shall be taken as the average of three counts made at different places on the sample. An accepted thread counting magnifying glass shall be used in making the counts.

TENSILE STRENGTH

Apparatus. 15. The tensile strength of the tape shall be determined on a testing machine which conforms to the requirements of the Standard Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76) of the American Society for Testing Materials,[1] and tests shall be made in the direction of warp only.

Procedure. 16. The specimens shall be tested in full section and the distance between jaws shall be 3 in.

Number of Tests. 17. At least five strength determinations shall be made and the average of these five tests are to indicate the strength of the roll.

NUMBER OF TESTS

Number of Rolls Tested. 18. From each shipment of tape at least three rolls shall be selected and the tests outlined shall be made on each roll. Failure of the first samples selected to conform to the requirements of the specifications will necessitate a selection of the same number of rolls for a second test.

Failure. 19. Failure of any of the tape to conform to the requirements of these specifications will make the shipment the subject of complaint and disposition in accordance with the agreement between the buyer and seller.

20. In case of dispute, tests shall be made on material under standard conditions as defined in Section 3 of the Standard General Methods of Testing Woven Textile Fabrics (A.S.T.M. Designation: D 39) of the American Society for Testing Materials.[2]

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1060.

[2] *Ibid.*, p. 1102.

TENTATIVE SPECIFICATIONS
FOR
ENAMELING DUCK FOR THE TIRE INDUSTRY[1]

A.S.T.M. Designation: D 336 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover both single and double-filling (2 ply) enameling duck made of carded American cotton for use in the tire industry.

SPECIFICATIONS

Properties. 2. Enameling ducks shall conform to the requirements specified in the following table, within the tolerances specified therein:

		Single Filling			Double Filling (2 ply)		
		Standard	Minimum	Maximum	Standard	Minimum	Maximum
Weight, oz. per sq. yd		8.6	8.35	8.85	8.6	8.35	8.85
Count	Warp	84	83	85	84	83	85
	Filling	28	27	29	28	27	29
Thickness (Gage), in		0.024	0.0228	0.0252	0.024	0.0228	0.0252
Yarn Size and Ply	Warp	13/1	....	....	13/1	....	....
	Filling	6.5/1	....	....	13/2	....	....
Tensile Strength,[a] Grab Test, Conditioned or Corrected, lb.	Warp	135	120	....	135	120	....
	Filling	75	65	....	80	70	....

[a] Values of tensile strength are based on tests made on a 400 to 800-lb. capacity horizontal testing machine of inclination balance type.

Tolerances. 3. Tolerances shall be the limits within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications.

METHODS OF TESTING

WIDTH

Width. 4. The average width shall be determined by measuring at five different places uniformly distributed along the full length of the roll or piece. No measurement shall be considered within 3 yd. of either end of the roll or piece.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

WEIGHT

Weight per Square Yard.

5. The net weight of the roll or piece from which the covering or binding has been removed shall be determined.

The net weight of the roll or piece divided by its standard area in square yards shall be taken as the normal net weight per square yard.

COUNT

Count.

6. The average number of ends and picks per inch of the fabric shall be determined by counting a space not less than 1 in. in five different places uniformly distributed along the full length of the roll or piece. No count shall be considered within 3 yd. of either end of the roll or piece.

THICKNESS (GAGE)

Thickness (Gage).

7. The average thickness of the fabric shall be determined by means of an automatic micrometer equipped with a foot $\frac{3}{8}$ in. in diameter. The foot of the micrometer shall be raised approximately $\frac{1}{4}$ in. above the fabric and allowed to drop under a dead weight pressure of 6 oz. Thickness measurements shall be taken in five different places uniformly distributed along the full length of the roll or piece. No thickness determination shall be considered within 6 in. of the selvage nor within 3 yd. of either end of the roll or piece.

TENSILE STRENGTH

Tensile Strength.

8. (*a*) The average tensile strength shall be determined by testing five samples each of warp and filling on an inclination balance or pendulum type machine.

(*b*) In selecting the proper capacity of the machine for the fabric to be tested, the maximum capacity of the machine shall not exceed that at which the pendulum reaches a swing of 45 deg. from the vertical. The minimum capacity of the machine shall not be less than 20 per cent of the above maximum capacity.

The minimum diameter of drum for transferring the pull on the specimen to the swinging pendulum shall be 2 in.

(*c*) Tensile strength tests shall be made by the grab method. Test specimens shall be cut 6 in. in length by 4 in. in width, and shall be taken at least 1 in. from the selvage. The bottom or back jaws shall be at least 2 in. in width, and the top or front jaws shall be 1 in. in width. The jaws shall be 3 in. apart and speed of pulling jaw shall be 12 in. per minute. Care shall be taken that the same set of threads is embraced by both pairs of jaws. The specimen shall then be strained to the point of rupture.

(*d*) Tensile strength shall be determined either in the standard condition or corrected to 7 per cent standard moisture regain, as follows:

Standard Condition.—The standard condition of woven textile fabric shall be understood to be the condition which it assumes on exposure for at least 4 hours. to an atmosphere having a relative humidity of 65 per cent at 70° F. (21.1° C.).

Corrected to Standard Moisture Regain (*7 per cent*).—Tensile strength determinations shall be corrected to 7.0 per cent standard moisture regain. Between the limits of 5 to 7.5 per cent regain, the corrected tensile strength shall be calculated by the following formula which allows 4.2 per cent increase or decrease in tensile strength for each 1 per cent variation from the standard regain:

$$\begin{array}{c}\text{Tensile strength corrected to}\\ \text{7 per cent moisture regain}\end{array} = \frac{\text{Actual tensile strength} \times 129.40}{100 + (4.2 \times \text{actual percentage regain})}$$

Example.—A fabric having a tensile strength of 110 lb. with 6 per cent moisture regain would have a corrected strength of 113.7 lb. at the standard moisture regain (7 per cent).

TENTATIVE SPECIFICATIONS AND TEST METHODS
FOR
ASBESTOS TAPE FOR ELECTRICAL PURPOSES[1]

A.S.T.M. Designation: D 315 – 31 T

This is a Tentative Standard, published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1929; REVISED, 1931.[2]

Scope.

1. These specifications cover asbestos tape woven from plain asbestos yarn and suitable for electrical purposes.

COMPOSITION

Cotton Content.

2. The asbestos tape shall be woven from Grade *A* plain asbestos yarn containing 15 to 20 per cent of cotton, conforming to the Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (A.S.T.M. Designation: D 299) of the American Society for Testing Materials.[3]

TENSILE STRENGTH

Tensile Strength.

3. The tensile strength of the tape per inch of width shall conform to the following minimum requirements:

THICKNESS, IN.	TENSILE STRENGTH, LB. PER IN. OF WIDTH
0.015	25
0.020	35
0.025	50
0.030	85

Tensile Strength After Heating.

4. The tensile strength of the tape per inch of width after being heated in an oven for five minutes at 300° C. shall not be less than 50 per cent of the values specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

[2] Revision approved by Committee E-10 on Standards, August 6, 1931.

[3] 1930 Book of A.S.T.M. Standards, Part II, p. 1099.

Number of Tests. 5. The tensile strength tests before and after heating shall each be made on five specimens, none of which shall break below the minimum values specified in Sections 3 and 4.

CONSTRUCTION

Ends and Picks. 6. The number of ends and picks per inch shall conform to the following requirements within plus 6 or minus 2 ends and plus 5 or minus 1 pick:

Thickness, in.	Ends per inch	Picks per inch
0.015	30	18
0.020	22	18
0.025	27	12
0.030	27	12

Weave. 7. The tape shall be uniformly woven and shall have selvage edges.

Metallic Particles. 8. The tape shall be practically free from microscopic particles of iron.

THICKNESS

Thickness. 9. The thickness of the tape shall not vary more than plus or minus 0.003 in. from the specified thickness.

WIDTH

Width. 10. The width shall not vary from that specified more than plus or minus $\frac{1}{32}$ in. for tape up to and including 1 in. in width, and plus or minus $\frac{1}{16}$ in. for tape over 1 in. in width.

YARDAGE

Yardage. 11. The number of yards per pound shall be not less than the following minimum requirements:

Width, in.	Thickness, in.	Yardage per pound
½	0.015	85
¾	0.015	65
1	0.015	50
1¼	0.015	40
1½	0.015	30
½	0.020	70
¾	0.020	53
1	0.020	40
1¼	0.020	32
1½	0.020	25
½	0.025	45
¾	0.025	35
1	0.025	25
1¼	0.025	18
1½	0.025	13
1	0.030	17
1¼	0.030	13½
1½	0.030	11

METHODS OF TESTING

COMPOSITION

Cotton Content Determination.

12. The cotton content and percentage of cellulose shall be determined in accordance with Sections 6 and 7 of the Standard Specifications for Tolerances and Test Methods for Asbestos Yarns (A.S.T.M. Designation: D 299) of the American Society for Testing Materials.[1]

TENSILE STRENGTH

Apparatus.

13. (*a*) The tensile strength shall be determined on a testing machine conforming to the requirements of the Standard Specifications for Textile Testing Machines (A.S.T.M. Designation: D 76) of the American Society for Testing Materials.[2]

Procedure.

(*b*) Tensile strength tests shall only be made in the direction of the warp. The specimens shall be tested in full section. The initial length of the test specimens between the jaws shall be 3 in. and the speed of the pulling jaw shall be 12 in. per minute.

CONSTRUCTION

Ends and Picks.

14. (*a*) The number of ends and the number of picks shall be taken as the average of five counts in five different places on the sample.

(*b*) The total number of ends shall be determined regardless of the width of the tape.

(*c*) The number of picks shall be determined in a length of 1 in.

THICKNESS

Method of Measuring Thickness.

15. The thickness shall be determined by a micrometer having measuring faces not less than $\frac{7}{16}$ in. nor more than $\frac{1}{2}$ in. in diameter. Readings shall be made while the micrometer faces hold the tape with just sufficient pressure to permit the tape to be moved without distorting the threads.

Number of Measurements.

16. The thickness shall be taken as the average of ten measurements at ten different places on the sample.

WIDTH

Method of Measuring Width.

17. The width shall be determined by the use of a standard steel scale graduated to within the degree of accuracy specified in Section 10. The determination shall be made with the material laid flat on a smooth surface.

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[1] 1930 Book of A.S.T.M. Standards, Part II, p. 1099.

[2] *Ibid.*, p. 1060.

18. The width shall be taken as the average of ten measurements at ten different places on the sample. **Number of Measurements.**

YARDAGE

19. The yardage shall be determined by accurately measuring a sample not less than 12 yards in length and weighing it on a balance sensitive to 0.5 per cent of the weight of the specimen. The length determination shall be made with the material laid flat on a smooth surface and held taut without stretching. **Method of Measuring Yardage.**

WORKMANSHIP AND FINISH

20. The workmanship shall be first class as shown by even spacing in the weave, freedom from nap and from broken threads, uneven threads, and knots. **Workmanship.**

21. The tape shall be calendered. **Finish.**

22. No sizing shall be used. **Sizing.**

PACKING

23. (*a*) The tape shall be wound in continuous rolls on bushings having a length $\frac{1}{16}$ in. shorter than the width of the tape and an inside diameter of $\frac{3}{8}$ in. or $\frac{1}{2}$ in. as specified by the purchaser. The bushings shall have sufficient strength to resist crushing in packing and shipment. **Rolls.**

(*b*) The rolls shall each contain 36 yd. of tape.

(*c*) The end of the tape shall be secured with a gummed label.

TENTATIVE SPECIFICATIONS
FOR
CHAFER TIRE FABRICS[1]

A.S.T.M. Designation: D 316 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1929; REVISED, 1930, 1931.

Scope. 1. These specifications cover commercial 8, 9, 12, and 14 oz. chafer tire fabrics made of carded American cotton of the following constructions:

8 oz.	20/3 ply (in both warp and filling)..	1 to $1\frac{1}{16}$-in. Staple Commercial Cotton
	14/2 ply (in both warp and filling)..	$\frac{15}{16}$ to 1-in. Staple Commercial Cotton
9 oz.	20/4 ply (in both warp and filling)..	1 to $1\frac{1}{16}$-in. Staple Commercial Cotton
	10/2 ply (in both warp and filling)..	$\frac{15}{16}$ to 1-in. Staple Commercial Cotton
12 oz...	12/4 ply (in both warp and filling)..	$\frac{15}{16}$ to 1-in. Staple Commercial Cotton
14 oz.	20/8 ply (in both warp and filling)..	1 to $1\frac{1}{16}$-in. Staple Commercial Cotton
	10/4 ply (in both warp and filling)..	$\frac{15}{16}$ to 1-in. Staple Commercial Cotton

Properties. 2. Chafer tire fabric shall conform to the requirements specified in Table I, subject to the tolerances specified therein.

Tolerances. 3. Tolerances shall be the limits within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications.

METHODS OF TESTING

WIDTH

Width. 4. The average width shall be determined by measuring at five different places uniformly distributed along the full length of the roll or piece. No measurement shall be considered within 3 yd. of either end of the roll or piece.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

TABLE I.—PHYSICAL PROPERTIES OF CHAFER TIRE FABRICS.

	8-oz. Fabric						9-oz. Fabric					
	20/3 Ply Construction			14/2 Ply Construction			20/4 Ply Construction			10/2 Ply Construction		
	Standard	Minimum	Maximum	Standard	Minimum	Maximum	Standard	Minimum	Maximum	Standard	Minimum	Maximum
Width, in.	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6
Weight, oz. per sq. yd.	8.1	7.85	8.35	8.1	7.85	8.35	9.25	8.97	9.53	9.25	8.95	9.55
Count, Warp	35	34.6	35.4	37	36.6	37	29	28.7	29.3	29	28.7	29.3
Count, Filling	37	35.5	38.5	39	37.5	40.5	31	30	32	31	30	32
Thickness (Gage), in.	0.023	0.0218	0.0242	0.023	0.0218	0.0242	0.0275	0.0260	0.0290	0.0275	0.0260	0.0290
Tensile Strength,[a] lb., Grab Test, Conditioned[b]., Warp	...	110	...	...	100	...	...	130	...	...	115	...
Tensile Strength,[a] lb., Grab Test, Conditioned[b]., Filling	...	120	...	...	110	...	...	140	...	...	125	...
Tensile Strength,[a] lb., Grab Test, Bone Dry[c], Warp	...	80	...	...	70	...	...	85	...	...	75	...
Tensile Strength,[a] lb., Grab Test, Bone Dry[c], Filling	...	85	...	...	75	...	...	95	...	...	85	...
Ply Twist, Warp	11.0	10.4	11.6	11.0	10.4	11.6	7.5	7.1	7.9	8.5	8.1	8.9
Ply Twist, Filling	11.0	10.4	11.6	11.0	10.4	11.6	7.5	7.1	7.9	8.5	8.1	8.9
Crimp, per cent, Warp	16	14.4	17.6	16	14.4	17.6	16	14.4	17.6	16	14.4	17.6
Crimp, per cent, Filling	8	6.4	9.6	8	6.4	9.6	8	6.4	9.6	8	6.4	9.6

	12-oz. Fabric			14-oz. Fabric					
	12/4 Ply Construction			20/8 Ply Construction			10/4 Ply Construction		
	Standard	Minimum	Maximum	Standard	Minimum	Maximum	Standard	Minimum	Maximum
Width, in.	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6	48 54 60	47.5 53.5 59.4	48.5 54.5 60.6
Weight, oz. per sq. yd.	12.0	11.7	12.3	14.3	13.9	14.7	14.3	13.9	14.7
Count, Warp	22.5	22.2	22.8	22.5	22.2	22.8	22.5	22.2	22.8
Count, Filling	23.5	23.0	24.0	23.5	23.0	24.0	23.5	23.0	24.0
Thickness (Gage), in.	0.033	0.0313	0.0347	0.038	0.036	0.040	0.038	0.036	0.040
Tensile Strength,[a] lb., Grab Test, Conditioned[b]., Warp	...	145	...	...	200	...	...	185	...
Tensile Strength,[a] lb., Grab Test, Conditioned[b]., Filling	...	155	...	...	210	...	...	195	...
Tensile Strength,[a] lb., Grab Test, Bone Dry[c], Warp	...	100	...	...	135	...	...	120	...
Tensile Strength,[a] lb., Grab Test, Bone Dry[c], Filling	...	110	...	...	145	...	...	130	...
Ply Twist, Warp	6.5	6.2	6.8	5.0	4.75	5.25	5.5	5.2	5.8
Ply Twist, Filling	6.5	6.2	6.8	5.0	4.75	5.25	5.5	5.2	5.8
Crimp, per cent, Warp	16	14.4	17.6	16	14.4	17.6	16	14.4	17.6
Crimp, per cent, Filling	8	6.4	9.6	8	6.4	9.6	8	6.4	9.6

[a] Tensile strength values are based on tests made on a 400 to 800-lb. capacity horizontal testing machine of inclination balance type.

[b] Preferred Method, in standard condition or corrected to standard moisture regain (6.5 per cent).

[c] Alternate Method, dry condition.

WEIGHT

Weight.

5. The net weight of the roll or piece from which the covering or binding has been removed shall be determined.

The net weight of the roll or piece divided by its standard area in square yards shall be taken as the normal net weight per square yard.

COUNT

Count.

6. The average number of ends and picks per inch of the fabric shall be determined by counting a space not less than 1 in. in five different places uniformly distributed along the full length of the roll or piece. No count shall be considered within 3 yd. of either end of the roll or piece.

THICKNESS (GAGE)

Thickness (Gage).

7. The average thickness of the fabric shall be determined by means of an automatic micrometer equipped with a foot $\frac{3}{8}$ in. in diameter. The foot of the micrometer shall be raised approximately $\frac{1}{4}$ in. above the fabric and allowed to drop under a dead weight pressure of 6 oz. Thickness measurements shall be made in five different places uniformly distributed along the full length of the roll or piece. No determination shall be considered within 6 in. of the selvage nor within 3 yd. of either end of the roll or piece.

TENSILE STRENGTH

Tensile Strength.

8. (*a*) The average tensile strength shall be determined by testing five samples each of warp and filling on an inclination balance or pendulum type machine.

(*b*) In selecting the proper capacity of the machine for the fabric to be tested, the maximum capacity of the machine shall not exceed that at which the pendulum reaches a swing of 45 deg. from the vertical. The minimum capacity of the machine shall not be less than 20 per cent of the above maximum capacity.

The minimum diameter of drum for transferring the pull on the specimen to the swinging pendulum shall be 2 in.

(*c*) Tensile strength tests shall be made by the grab method. Test specimens shall be cut 6 in. long by 4 in. wide, and shall be taken at least 1 in. from the selvage. The bottom or back jaws shall be at least 2 in. wide, and the top or front jaws shall be 1 in. wide. The jaws shall be 3 in. apart and the speed of pulling jaw shall be 12 in. per minute. Care shall be taken that the same set of threads is embraced by both pairs of jaws. The specimen shall then be strained to the point of rupture.

(*d*) Tensile strength shall be determined either by the preferred method, with the fabric in standard condition or corrected to 6.5 per cent standard moisture regain, or by the alternate method with the fabric in dry condition, as follows:

Preferred Method, Standard Condition.—The standard condition of woven textile fabric shall be understood to be the condition which it assumes on exposure for at least 4 hours to an atmosphere having a relative humidity of 65 per cent at 70° F. (21.1° C.).

Preferred Method, Standard Moisture Regain (*6.5 per cent*).—Tensile strength determinations shall be corrected to 6.5 per cent standard moisture regain. Between the limits of 5 to 7 per cent regain, the corrected tensile strength shall be calculated by the following formula which allows 4.7 per cent increase or decrease in tensile strength for each 1 per cent variation from the standard regain:

$$\text{Tensile strength corrected to 6.5 per cent moisture regain} = \frac{\text{Actual tensile strength} \times 130.55}{100 + (4.7 \times \text{actual percentage regain})}$$

Example.—A fabric having a tensile strength of 210 lb. with 6 per cent moisture regain would have a corrected strength of 213.8 lb. at the standard moisture regain (6.5 per cent).

Alternate Method, Dry Condition.—The dry condition of woven textile fabrics shall be understood to be absolute dryness obtained by placing the material in a ventilated drying oven maintained at a temperature of from 100 to 110° C. (212 to 230° F.) and drying to constant weight as determined by two consecutive weighings without removal from the oven, to be taken not less than ten minutes apart, and showing a further loss of not more than 0.1 per cent from the previous weighing.

TWIST

9. The ply twist of warp or filling shall be based on ten tests, each taken on any standard twist counter with the jaws set 10 in. apart. Each test specimen shall be clamped in the jaws under a definite tension by attaching weights. The tension to be used shall be determined from the formula: **Twist.**

$$\text{Tension (in grams)} = \frac{156 \text{ (constant)}}{\text{Theoretical yarn size}}$$

Example.—The weight to be attached for 20/4 ply would be as follows:

$$\frac{156}{5} = 31 \text{ g. (approximate)}$$

CRIMP

Crimp. 10. (*a*) The average crimp of warp or filling shall be determined by testing at least four adjacent samples each of warp and filling yarns under standard conditions.

(*b*) Two parallel lines shall be marked on the fabric at least 6 in. apart. Four threads shall be ravelled out, long enough to extend about 2 in. beyond each mark. These threads shall be straightened by a machine which applies a load to each thread. The load (in grams) to be used is 156 divided by the equivalent singles size of the thread. The crimp shall be the ratio between the final length of the thread and its original length in the cloth.

$$\text{Crimp, per cent} = \frac{(B - A)}{A} \times 100$$

where A = length of yarn in fabric; and
B = length of yarn after removal from fabric and straightened.

TENTATIVE METHOD OF DETERMINING RELATIVE HUMIDITY[1]

A.S.T.M. Designation: D 337 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Definitions.

1. (*a*) *Absolute Humidity.*—Actual density of water vapor in the atmosphere, usually expressed in grains per cubic foot.

(*b*) *Relative Humidity.*—Ratio of actual density (or pressure) of existing vapor, to maximum possible density (or pressure) at the same temperature, expressed as a percentage.

(*c*) *Dew Point.*—Temperature at which condensations of moisture would occur if the existing atmosphere were cooled without change in vapor pressure.

(*d*) *Vapor Pressure.*—Component of atmospheric pressure caused by presence of water vapor, usually expressed in inches of mercury.

(*e*) *Dry Bulb Temperature.*—Temperature of the air as indicated by a standard thermometer.

(*f*) *Wet Bulb Temperature.*—For purposes of this method, temperature indicated by the wet bulb thermometer of a standard sling psychrometer or its equivalent. Theoretically, temperature at which the atmosphere would become saturated by evaporation of water without loss or gain in total heat content of the air and vapor.

(*g*) *Hygrometer.*—Any properly calibrated instrument which indicates directly or indirectly the humidity of the air.

(*h*) *Absorption Hygrometer.*—Any one of several types of hygrometers containing a hygroscopic substance the length, thickness or weight of which is a measurable index of the humidity of the atmosphere. Usually such devices are graduated directly either in relative humidity or in regain of stock in process, and are continuously indicating.

(*i*) *Wet and Dry Bulb Hygrometer or Psychrometer.*—Contains two matched thermometers, one plain and one having a wet bulb covering as hereinafter specified—for simultaneously indicating the dry and wet bulb temperatures of the atmosphere.

(*j*) *Recording Hygrometer or Psychrometer.*—Any approved type of hygrometer or psychrometer equipped with automatic clocking and recording device capable of making a continuous time—relative humidity autograph or time—wet and dry bulb temperature autograph.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

(*k*) *Sling Psychrometer.*—A psychrometer containing matched dry and wet bulb thermometers suitably mounted for swinging through the atmosphere, for simultaneously indicating dry and wet bulb temperatures. The thermometers shall be so mounted as to act independently and to face the air current during swinging.

APPARATUS

Sling Psychrometer.

2. *Approved Instrument.*—The sling psychrometer shall be the standard instrument for measuring relative humidity, and for calibrating all other humidity measuring instruments. The sling psychrometer shall conform to the following requirements:

Thermometers.—Two mercury thermometers, stem graduated in degrees Fahrenheit or finer, matched to within $\frac{1}{4}$° F. throughout the range used.

NOTE.—Thin mercury bulbs have the advantage of sensitivity, requiring less time for swinging and giving quicker response to changes in atmospheric conditions.

Wet Bulb Covering.—The bulb of the wet bulb thermometer shall be completely covered with a close fitting fabric of mercerized cotton, silk or other soft unsized material, preferably tubular knitted. This material shall be kept clean and free from all foreign substances likely to affect the absorption or evaporation of moisture.

Alternative Instruments.

3. (*a*) Except in the case of dispute, other wet and dry bulb psychrometers which have provision for maintaining a definite movement of air across the sensitive elements of the thermometers may be used, provided their indications have been proved equivalent to those of a standard sling psychrometer within the allowable limits of accuracy.

(*b*) Except in the case of dispute, various types of absorption hygrometers (preferably those containing human hair) may be used, provided they are carefully calibrated at sufficiently frequent intervals to agree with indications of a standard sling psychrometer within the allowable limits of accuracy.

PROCEDURE

Procedure.

4. (*a*) *Preparing Instrument.*—The covering of the wet bulb shall be thoroughly moistened with water, preferably distilled water at approximately room temperature. A small bottle will serve as a convenient water container. If new or dry through disuse, several minutes may be required for complete saturation of the fabric. Touching

the fabric with the fingers, which may deposit oil or dirt, should be avoided. The dry bulb shall be maintained absolutely dry.

(*b*) *Swinging Instrument.*—The handle of the psychrometer shall be grasped and the instrument whirled, preferably in a vertical plane, with sufficient rapidity to give the wet bulb a velocity of from 10 to 20 ft. per second. The purpose of whirling is effectively to expose the thermometer to the action of the air until the minimum wet bulb temperature is indicated. Whirling shall be continued for a minimum of 30 seconds if the mercury bulbs are thin, and for about 60 seconds if they are thick. The operator should preferably stand facing the air current, and locations where proximity to machinery, direct heat from the sun or other sources which would have undue influence should be avoided.

(*c*) *Reading Instrument.*—Immediately after whirling the instrument the thermometers shall be read quickly. It is usually preferable to read the wet bulb first. For commercial accuracy, readings shall be made to the nearest ½° F. Greater accuracy may be secured by reading to the nearest ¼° F. or closer. The hands, face and other warm objects shall be kept as far as possible from the mercury bulbs while the thermometers are being read.

(*d*) For purposes of checking, the instrument shall again be whirled for about 20 seconds and another reading made. If necessary, this shall be continued until two successive readings agree. If atmospheric conditions are fluctuating it may be desirable to obtain several readings in order to secure an average. It will not be necessary to rewet the covering on the wet bulb so long as the fabric remains visibly damp.

(*e*) If the wet bulb temperature is below freezing, special care and patience are necessary in making an observation. As the moisture on the wet bulb begins to freeze, its temperature becomes 32° F. and remains so until freezing is completed. The temperature of the ice-covered bulb will then slowly descend until the true minimum is reached. Several minutes may be required to secure a correct reading in such a case.

Determination of Relative Humidity.

5. (*a*) Subtract the wet bulb reading from the dry. The difference is the "wet bulb depression." Knowing the temperature and the wet bulb depression, the relative humidity may be calculated from the following basic formula;[1]

$$e = e' - 0.000367P(t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

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[1] The basic formula is that deduced by Mr. Ferrel. It is found in the Smithsonian Meteorological Tables and in Report No. 235 of the Weather Bureau, Department of Agriculture, 1915.

where e = actual vapor pressure of the atmosphere, in inches of mercury;
e' = saturated or maximum vapor pressure at temperature t', in inches of mercury;[1]
P = barometric pressure in inches of mercury (see Note);
t = dry bulb temperature, in degrees Fahrenheit; and
t' = wet bulb temperature as shown by the sling psychrometer, in degrees Fahrenheit.

NOTE.—*Effect of the Barometer.*—Except for precise scientific measurements, changes in barometric pressure in any given locality are of negligible importance as affecting the accuracy of psychrometric humidity observations. Consequently in locations at or near the sea level (within 1000 ft. elevation) no consideration need be given to the height of the barometer. In the case of tests made at high altitudes or under conditions of excessive plenum, special tables should be used. A set of tables for various barometric pressures may be found in Report No. 235 of the U. S. Weather Bureau.

Relative humidity may be calculated from the relation:

$$\text{Relative humidity (per cent)} = \frac{100\,e}{E}$$

where E = saturated or maximum vapor pressure at temperature t.[1]

(*b*) For determining relative humidity from psychrometric observations within the normal temperature range 0° F. to 112° F., and for normal barometric pressure, 29 to 31 in., reference may for convenience be made to tables, charts, calculating devices, etc., provided they agree with the basic formula within the allowable limits of accuracy.

ACCURACY

Accuracy. 6. Distinction shall be made between the degree of accuracy satisfactory for ordinary commercial testing and that required of the laboratory technician.

(*a*) *Commercial Testing.*—For ordinary commercial testing, measured relative humidity shall not be more than 2 per cent above or below the relative humidity indicated by a standard sling psychrometer properly operated.

(*b*) *Laboratory Testing.*—For close laboratory testing, or in case of dispute, measured relative humidity shall not be more than 1 per cent above or below the relative humidity indicated by a standard sling psychrometer properly operated.

NOTE.—Under ordinary conditions, 1 per cent error in relative humidity corresponds to approximately $\frac{1}{2}$° F. error in wet bulb depression.

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[1] See Smithsonian Meteorological Tables for table of saturated vapor pressures.

TENTATIVE METHODS FOR IDENTIFICATION OF TEXTILE FIBERS AND THEIR QUANTITATIVE DETERMINATION IN MIXED GOODS[1]

A.S.T.M. Designation: D 276 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1927; Revised, 1929, 1930, 1931.

General Characteristics and Appearance of the Most Important Textile Fibers

Cotton:

Cotton, including several different kinds, consists of seed hairs obtained from different species of plants of the genus *Gossypium.* The kinds most used are American Upland cotton from *Gossypium hirsutum,* Sea Island from *Gossypium barbadense,* Egyptian supposed to be from a hybrid derived in part from *Gossypium barbadense,* India cotton from *Gossypium herbaceum* and Chinese cotton from *Gossypium nanking.*

Normal cotton fibers appear as long, colorless, twisted, ribbon-like cellular structures with thickened edges, due to the collapse of the original hollow cylindrical structure or tube. Most fibers have a flattened central air-filled canal or lumen. The length of the fibers varies with the variety from about ½ to 2 in. and the diameter or ribbon width from about 0.00063 to 0.00090 in. The number of natural twists or convolutions along the fibers varies considerably, ranging from about 159 to 225 per in. These twists occur in both directions.

Flax or Linen:

Flax fibers are bast fibers from the inner bark of the flax plant, *Linum usitatisaimum.*

Flax fibers consist of groups of cells, and these ultimate cells are long pointed, colorless and fairly uniform in structure. The central lumen often indistinct and sometimes appearing double, is narrow compared with the thickness of the cell wall.

Characteristic slight swellings or nodes are to be found at fairly regular intervals, with fine almost invisible cross-lines. The nodes, discolorations and cross-lines are more pronounced in woven fabrics than in raw flax, and recent studies indicate that the cross-lines which have been regarded as especially characteristic of flax, seem to be produced chiefly by the methods of extracting and cleaning the fiber.

Individual flax fibers vary in diameter, from coarse or fine stemmed plants and also depending on how much it has been combed or split up.

Commercial flax usually runs about 20 in. in length, but some fibers may run up to 36 in. or even longer. The ultimate cells of flax range from 15 to 50 mm. (0.6 to 2.0 in.) but in actual practice the fibers are rarely, if ever, reduced to their ultimate cells. In woven fabrics, linen yarns often show a characteristic abrupt change in diameter due to fibers being partly split off in hackling. In contrast to this, cotton yarns vary in size in a tapering manner.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

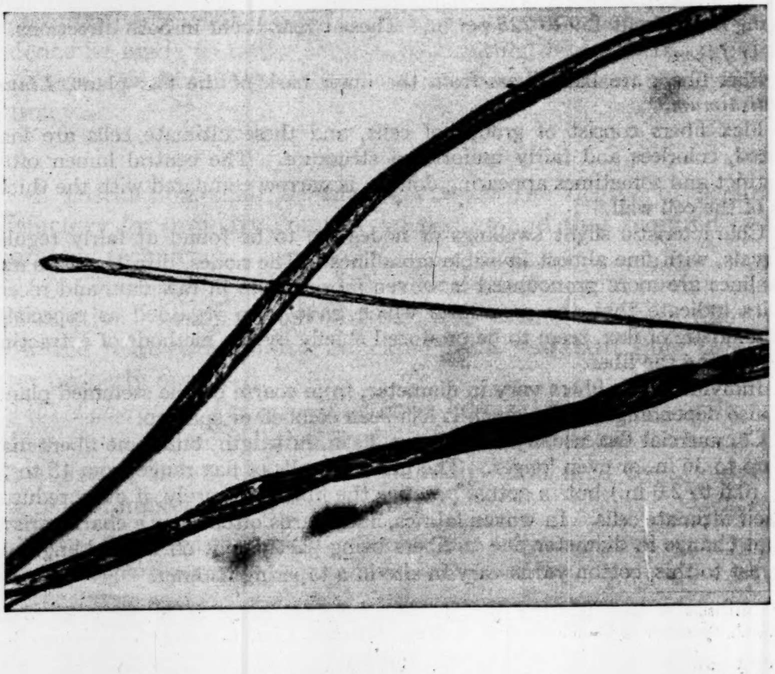

FIG. 1.—Longitudinal View of Cotton (× 250).

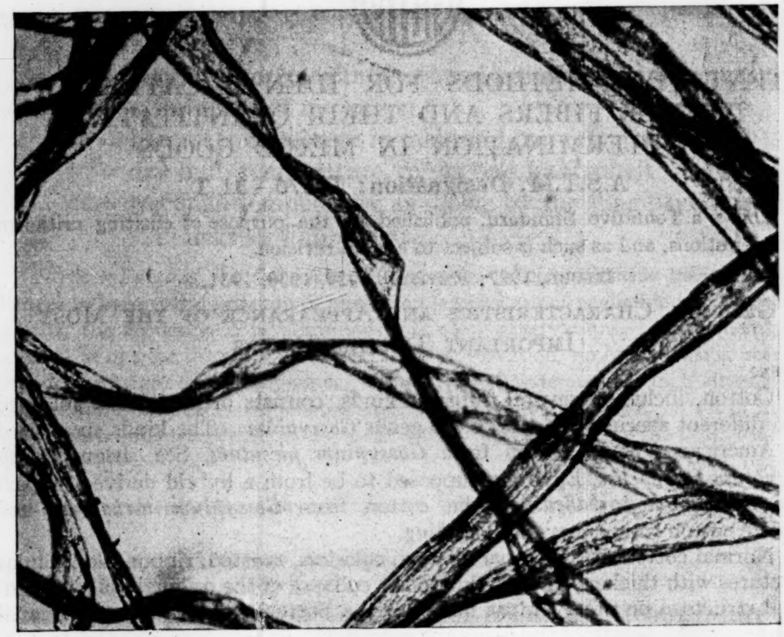

FIG. 2.—Longitudinal View of Immature Cotton (× 500).

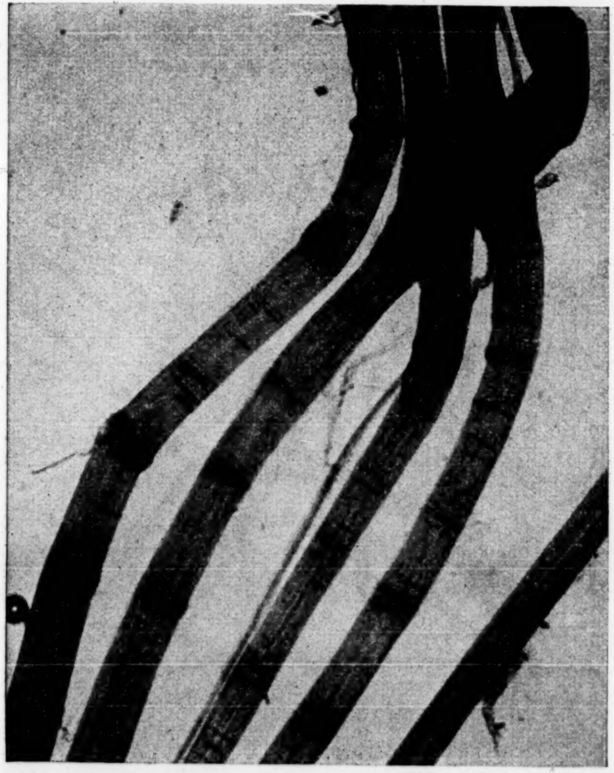

FIG. 3.—Longitudinal View of Flax or Linen Fibers (× 220).

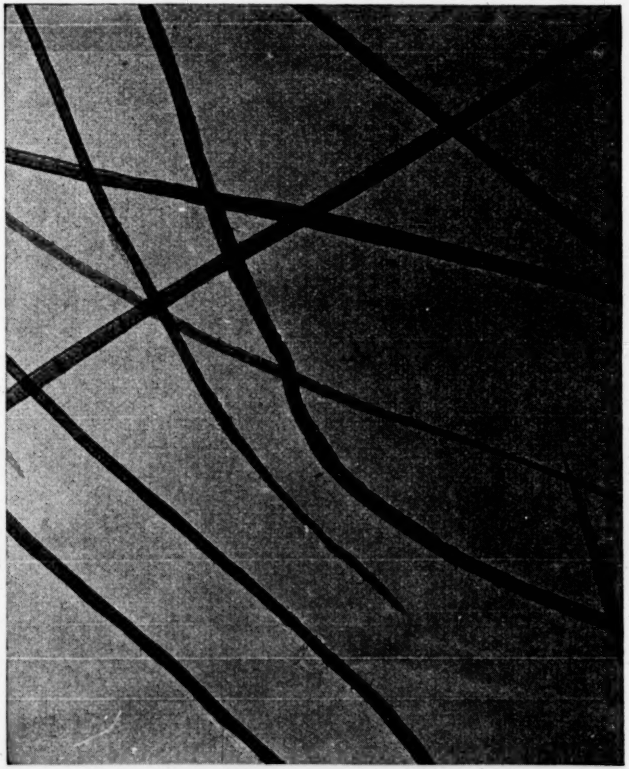

FIG. 4.—Longitudinal View of Hemp (*Cannabis Sativa*) (× 100).

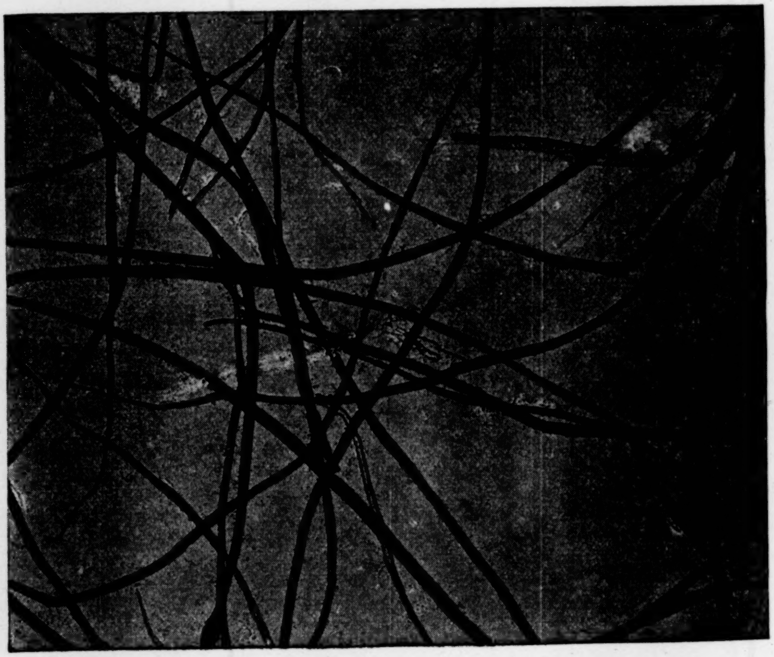

FIG. 5.—Longitudinal View of Jute (× 100).

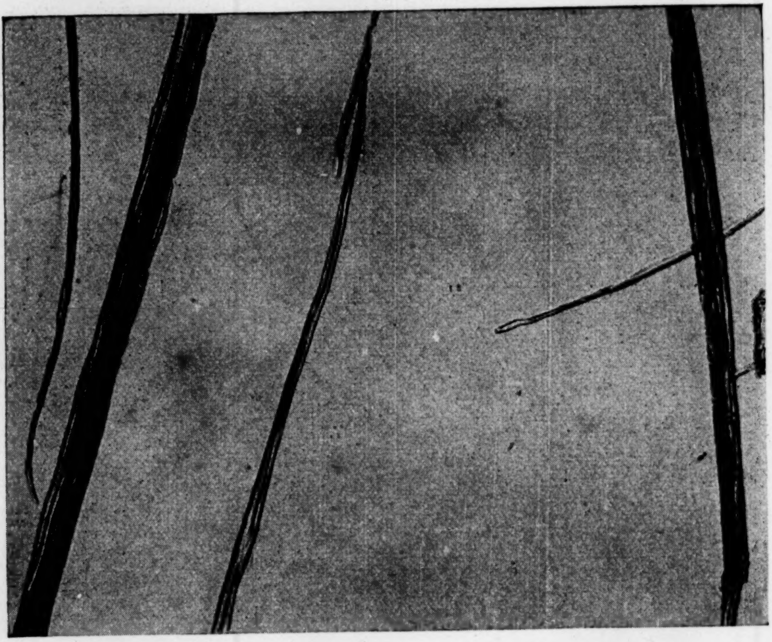

FIG. 6.—Longitudinal View of Jute (× 100).

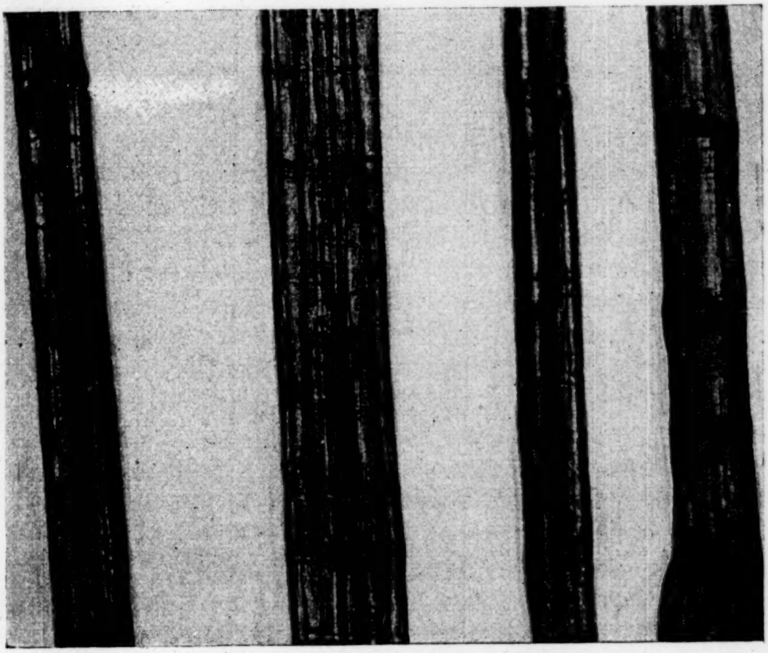

FIG. 7.—Longitudinal View of Ramie (× 250).

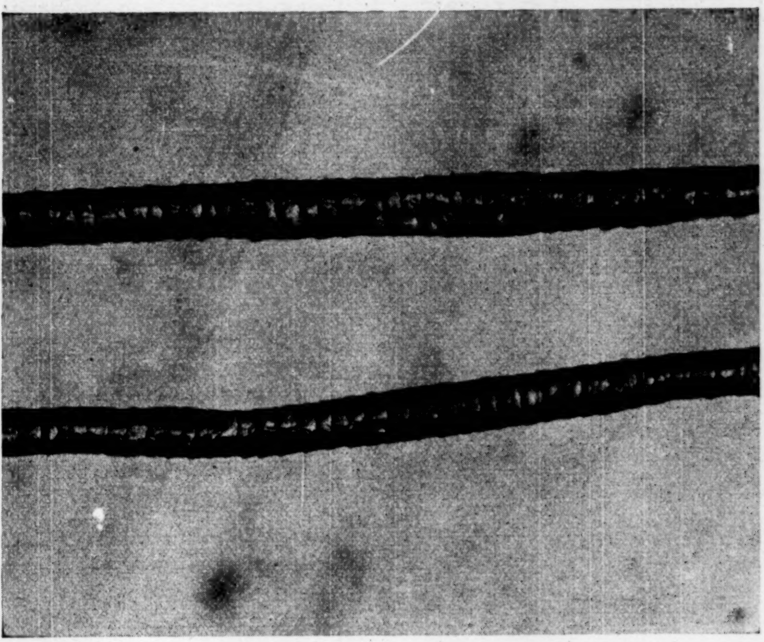

FIG. 8.—Longitudinal View of Wool (× 250).

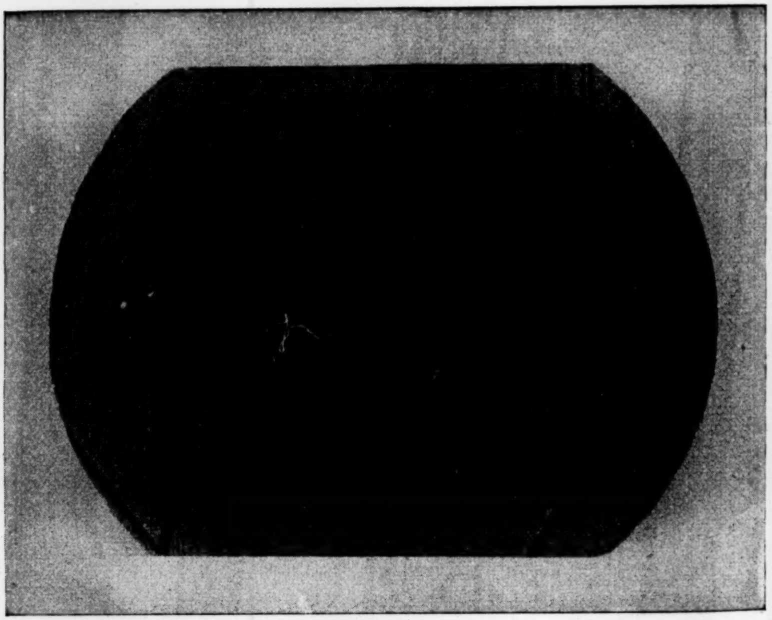

FIG. 9.—Longitudinal View of Silk (× 100).

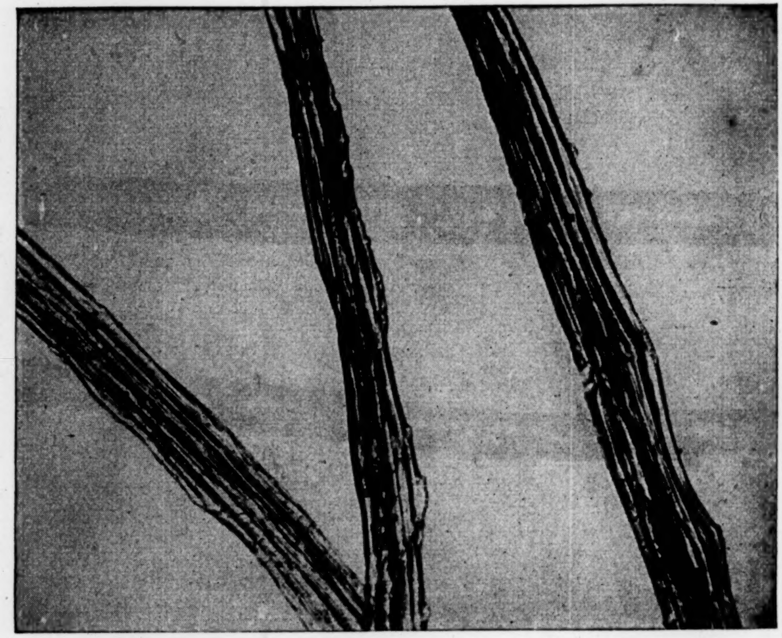

FIG. 10.—Longitudinal View of Raw Jap Silk (× 100).

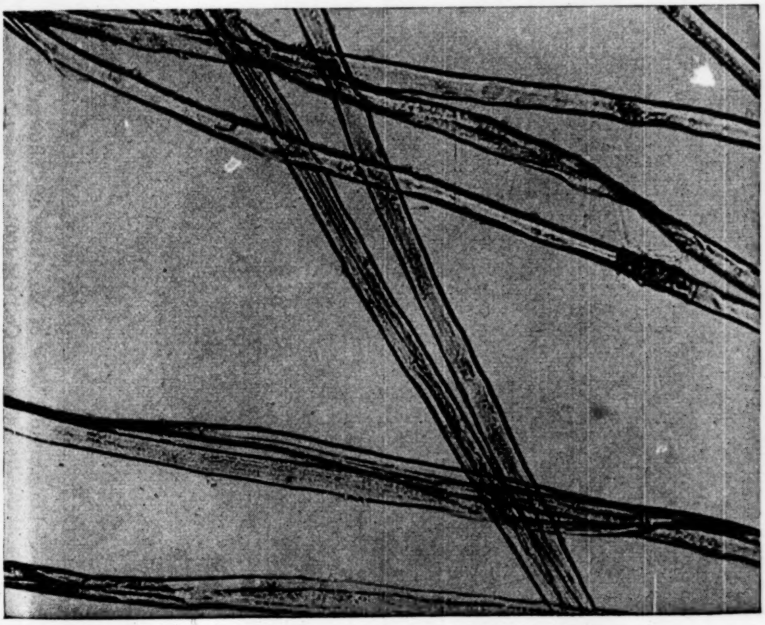

FIG. 11.—Longitudinal View of Tussah Silk (× 100).

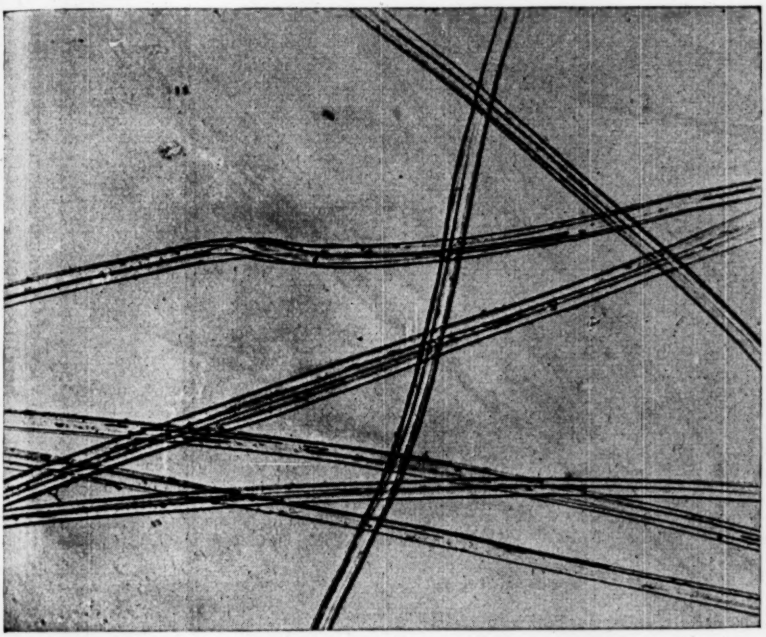

FIG. 12.—Longitudinal View of Cellulose Acetate Rayon (Celanese) (× 100).

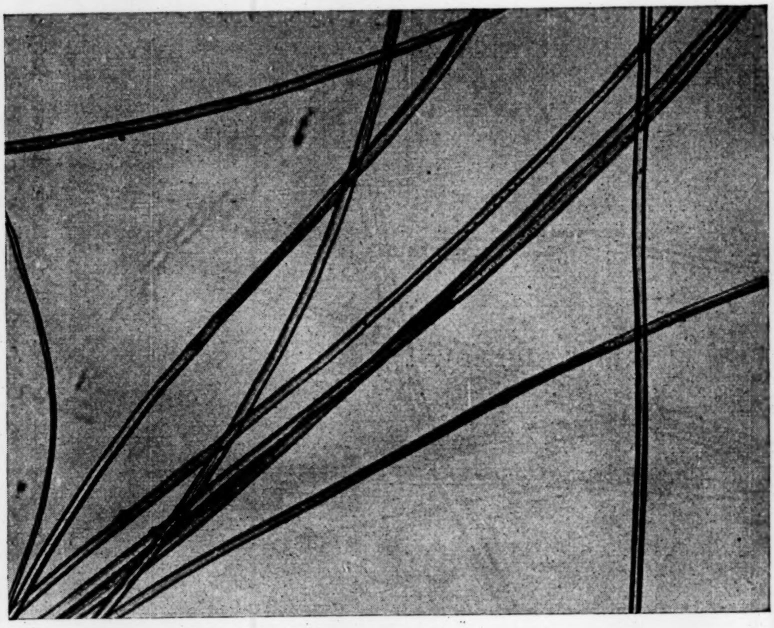

FIG. 14.—Longitudinal View of Cuprammonium Rayon (Bemberg) (× 100).

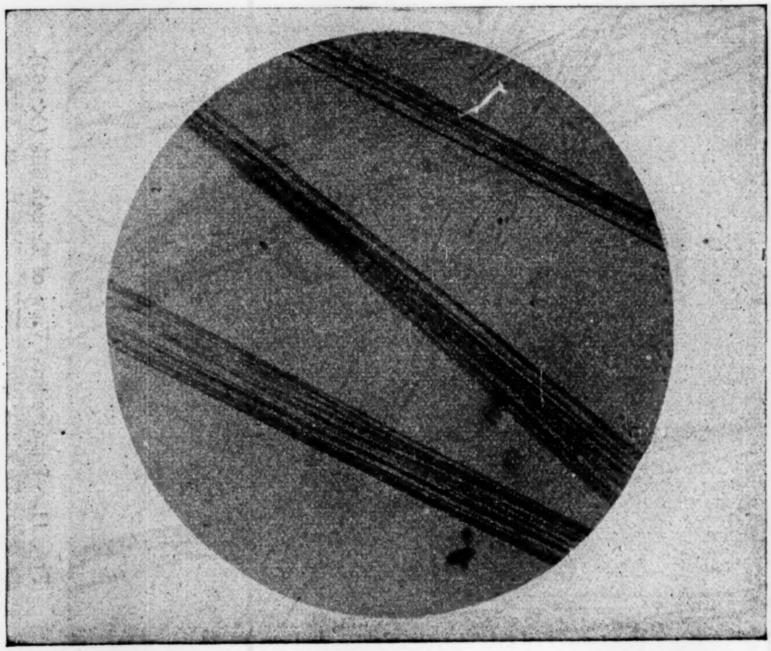

FIG. 13.—Longitudinal View of Xanthate of Cellulose Rayon (Viscose Co.) (× 100).

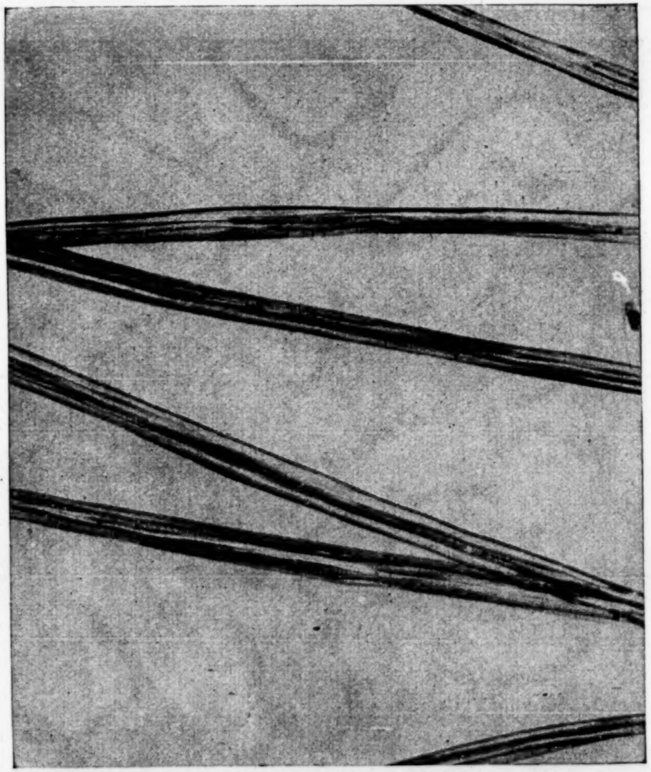

FIG. 15.—Longitudinal View of Nitro-cellulose Rayon (Tubize) (× 100).

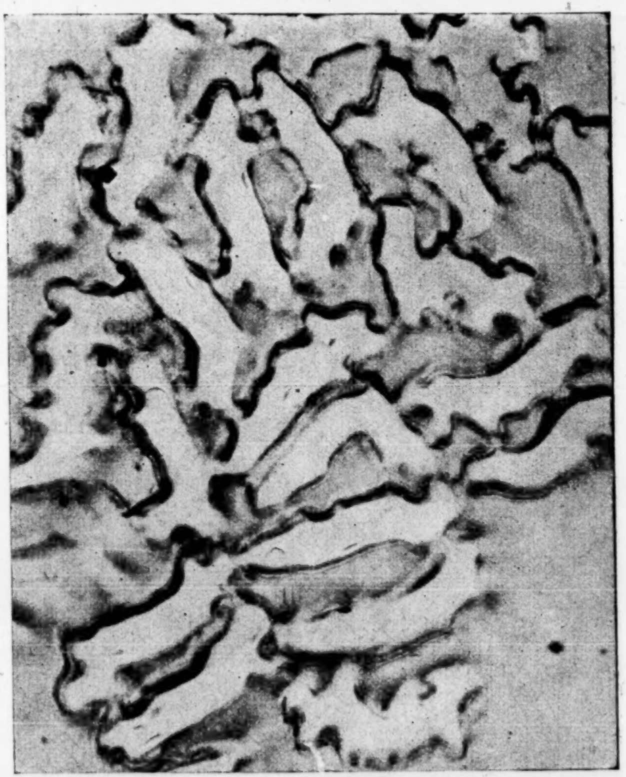

FIG. 16.—Cross-Section of Viscose Rayon, 150 Denier (DuPont Unbleached) (× 500).

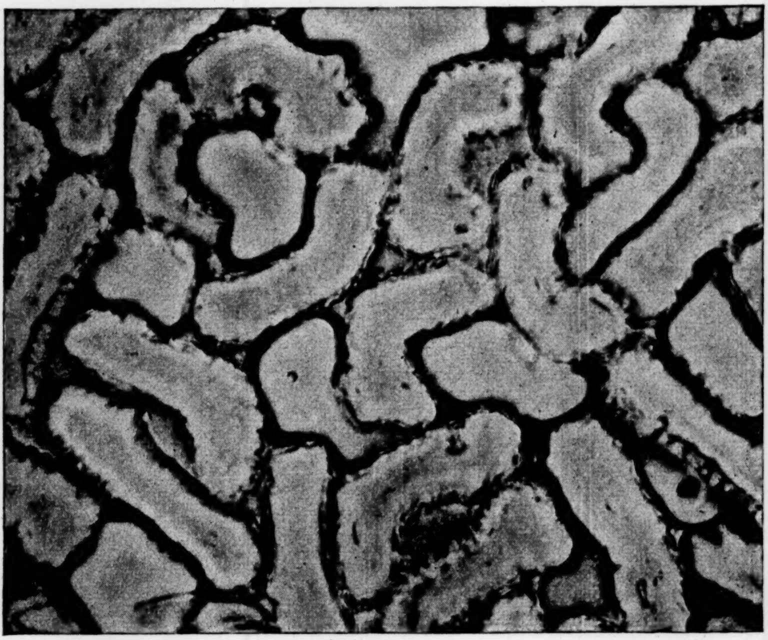

FIG. 17.—Cross-Section of Viscose Rayon, 300 Denier (Industrial Fiber Co.) (× 500).

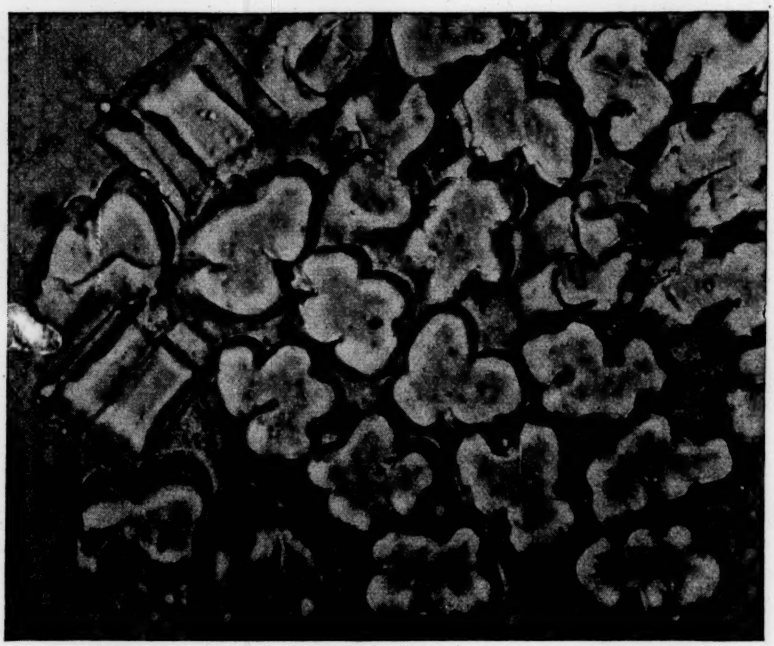

FIG. 18.—Cross-Section of Acetate Rayon, 150 Denier (Celanese) (× 500).

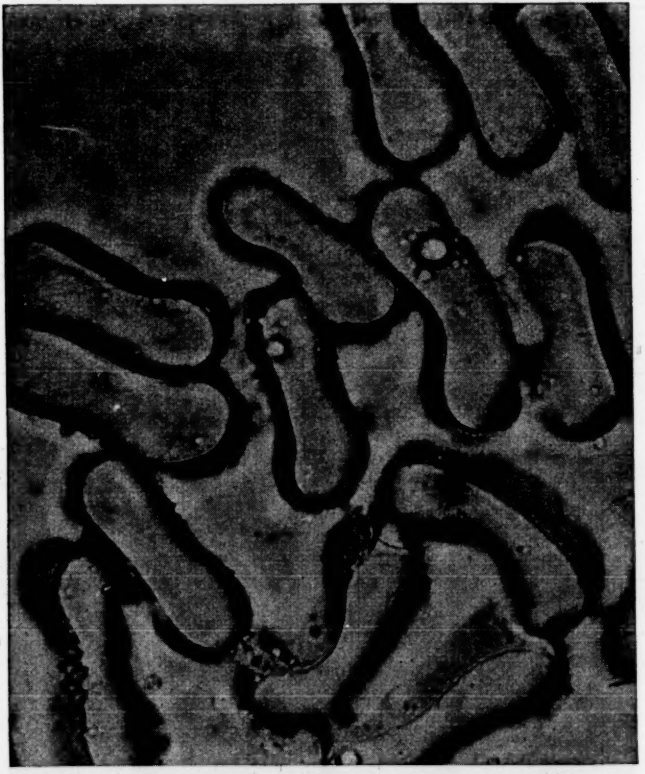

FIG. 19.—Cross-Section of Acetate Rayon, 150 Denier (Lustron Co.) (× 500).

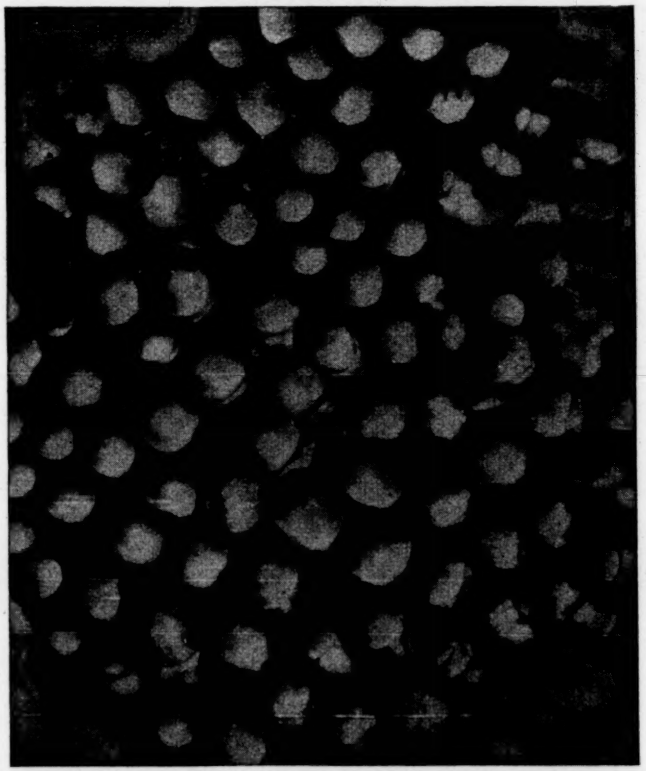

FIG. 20.—Cross-Section of Cuprammonium Rayon, 150 Denier (Bemberg) (× 500).

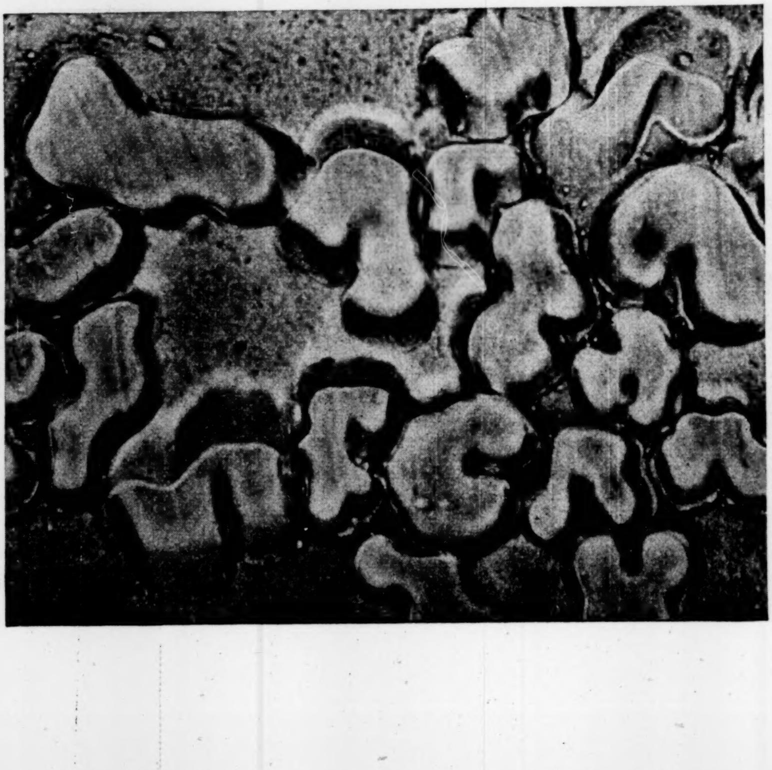

FIG. 21.—Cross-Section of Nitro-cellulose Rayon, 150 Denier (Tubize) (× 500).

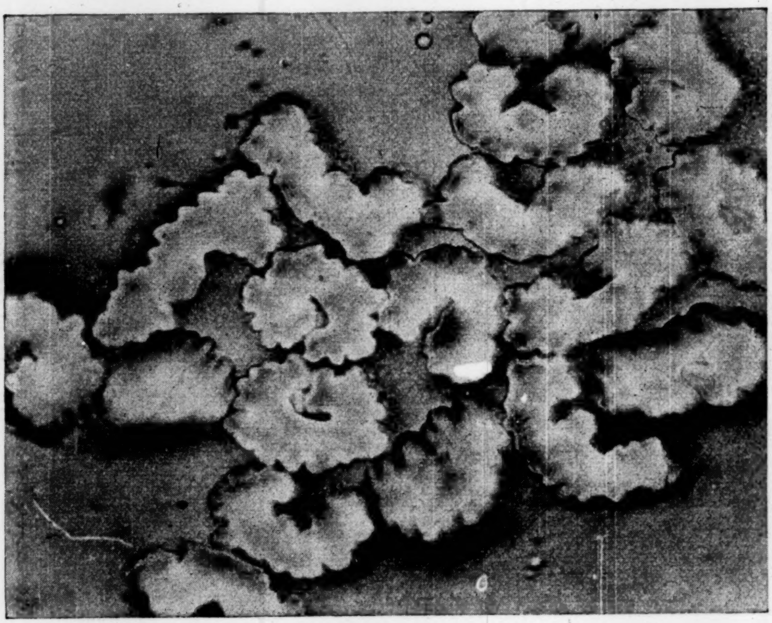

FIG. 22.—Cross-Section of Viscose Rayon, 150 Denier (Viscose Co.) (× 500).

Hemp (Common hemp, *Cannabis sativa*):

Hemp fibers are bast fibers from the inner bark of the hemp plant, *Cannabis sativa.*

Hemp fibers are composed of groups of long, blunt cells, not pointed at the ends as flax, though often of a forked shape. They all show large, well-defined lumens equal to or exceeding the thickness of the walls. There are usually pronounced longitudinal striations, and cross-lines are prominent, as are dislocations or folds, swellings and cross-fissures. The cell cross-sections are irregularly oval; the lumen flattened and irregular.

The commercial fibers are usually 3 to 8 ft. in length and in some kinds may be even longer. Dew-retted hemp is gray; water-retted hemp is light yellow; and steam or peeled and scraped hemp is semi-translucent.

There are several fibers miscalled hemp, but all are distinctly different from true hemp, and also different from each other. The following list indicates some of these fibers which are actually used in commerce:

- Soft Fibers
  - Sunn
  - Ambari
  - Roselle
- Hard Fibers
  - Abaca (Manila Hemp)
  - Henequen
  - Sisal
  - Cantala
  - Pitera
  - Mescal
  - Jaumave
  - Tula
  - Palma

Jute:

Jute fibers are bast fibers from the inner bark of two closely related plants, India jute, *Corchorus capsularis*, and Desi jute, *Corchorus olitorius.*

Jute fibers appear as bundles of fibers, shorter than hemp, with tapering and more pointed ends than hemp. The lumen is oval shaped, almost central, large and well defined, at times as wide or wider than the cell-walls and often remarkably constricted. The cross-sections of the cells are polygonal, five or six sided. There are longitudinal striations but no transverse markings nor jointed ridges. Externally the fibers are smooth and lustrous.

The prepared fibers may run from 4½ to 8 ft. in length and the crude fibers may be as long as 14 ft.

Ramie (Rhea):

Ramie fibers are bast fibers from the inner bark of the ramie or rhea plant, *Boehmeria nivea.*

Ramie fibers are long, somewhat tapering cells of uneven diameter with thick rounded ends. The diameter is irregular and the central canal or medullary space is sometimes quite distinct and at other times disappearing entirely. The canals are filled with granular matter and occupy from one-third to one-half the diameter. In cross-section the cells are more or less irregularly elliptical, but are often flattened and show very characteristic prominent cross-lines or fissures. The cell-walls are coarse, thickened irregularly at intervals, usually exhibiting well-marked nodes, joints, and discolorations. There are many prominent deep longitudinal striations, crossed at irregular intervals.

Ramie is stronger than the other vegetable fibers but lacks their extensibility and flexibility.

Wool:

Wool hairs under the microscope show an outer scaly layer or cuticle and an inner fibrous layer or cortex which may or may not be pigmented, and a central canal or medulla, usually filled with more or less interrupted granular-appearing matter. The epidermal scales on the surface of the fiber can be readily discerned, even under low power magnification and these instantly distinguish the fiber from silk or vegetable fibers. The scales are more or less translucent in appearance and permit of the under cortical layer being seen through them. The nature, structure, and arrangement of the scales differ considerably with different varieties of wool. The epidermal layer of scales imparts to the wool fiber its characteristic quality of luster through the reflection of light from the surface.

The cortical layer or true fibrous portion of the fiber forms the major constituent of wool. It consists mainly of more or less elongated cells and often presents a distinctly striated appearance, the striations being visible through the translucent layers of scales. When fiber is fine in staple, the cortical cells exhibit more or less unevenness in their growth and arrangement, with the result that the fiber is contracted on one side or the other, causing the wavy appearance of such wools. Coarse wools seldom exhibit the wavy structure.

Silk:

Silk filaments after de-gumming have the appearance of a single, fine, structureless, cylindrical, transparent filament (rarely striated longitudinally), flattened in spots, and in cross-section round or irregularly oval.

The fibers are many hundreds of yards long.

Wild Silk (Tussah Silk):

Wild silk consists of flattened, ribbon-like filaments of much greater width than the mulberry silk, with many fine, longitudinal striations, and with frequent oblique depressions where the fibers have crossed one another in the cocoons. Such silks are obtained from a variety of species of silk worms other than those from which the cultivated silk (*Bombyx mori*) is obtained. The silks are usually brownish in color.

Rayons:

Viscose rayons appear to consist of ribbons scored with deep longitudinal striations. The cross-section of the filaments varies from irregular ovals to long and narrow figures which may be either straight or bent with rounded crescents. The ends of the figure are rounded, the sides are scored by notches corresponding to the longitudinal striations of the filament.

Cuprammonium (or cuprate) rayons appear as smooth rods quite uniform in diameter with sometimes fine longitudinal striations. The cross-section is oval or round.

Nitro-cellulose or collodion rayons appear as if composed of several very fine filaments which adhere to each other throughout their length. The cross-section appears as rounded figures attached to one another.

Acetate rayons appear as transparent structureless filaments with only fine striations. The cross-sections are ovals which are flattened or indented at several points or sides.

FIBER MICROSCOPY

Fiber microscopy requires a certain amount of delicate technique and skill and a knowledge of proper methods of preparing and mounting specimens for examination as well as of the proper selection of lenses. Care and skill resulting from considerable practice are required to bring out the markings and structure of the various fibers.

Microscope.—A reasonably good microscope together with a good system of first-class lenses is essential. The following table gives a suitable range of magnifications obtained from the objectives and eyepieces noted:

	Magnification	
Objective	Eye-Piece No. 5	Eye-Piece No. 10
4 mm	200	400
8 mm	100	200
16 mm	50	100

It is an advantage to have the microscope fitted with a revolving nose-piece suitable for the three objectives, in which case the specimen can be readily located and viewed under different magnifications. An adjustable stage is also a convenience in locating different portions of the mount as well as in focussing. With a sub-stage diaphragm and condenser, proper conditions of illumination can be easily obtained. These are usually supplied with a good microscope.

Mounting of Specimens.—For all practical purposes and where it is not necessary to preserve the slides with their mounts, the specimens may be mounted in water. A few fibers should be well separated or teased with suitable implements and cut in convenient lengths, if necessary, after which they are laid on the slide and moistened with a drop of water. The cover-glass is placed over them and gently pressed down so as to flatten the specimen. It is usually preferable to confine the specimen to few rather than many fibers in order to avoid tangles and distortion. If permanent mounts are desired the fibers may be mounted in Canada Balsam which dries and cements the cover-glass firmly in place. Such mounting, however, is not recommended until considerable experience in fiber microscopy has been gained.

QUANTITATIVE SEPARATION OF THE MOST COMMON TEXTILE FIBERS

SELECTIVE DYEING TESTS FOR QUALITATIVE IDENTIFICATION

When little or nothing is known concerning the fibers present in a sample, it will be found desirable to first apply the following selective dyeing tests, which will indicate qualitatively the nature of the fibers present, after which more definite qualitative and finally quantitative tests may be applied.

Stripping of Sample.—If the fibers have already been dyed when received, the dye should be stripped off before making the test. This can usually be accomplished by boiling in a 3-per-cent solution of sodium hydrosulfite. After the color has been stripped, wash the material thoroughly with water to remove the stripping agent. All percentages given are based on the weight of the goods dyed.

Dyeing Tests.—Treat a piece of the sample in a solution of NaCl (3-per-cent) and Newport Direct Sky Blue FF (3-per-cent). Viscose takes a full shade of blue, while cellulose acetate is undyed.

Dye a piece of the sample at boiling for 30 minutes in a dye bath containing ·1 per cent of indigo carmine and 2 per cent of acetic acid. Work the goods thoroughly while dyeing, then remove and wash well with water. Wool or silk take a full shade, while cotton and rayon are undyed.

Dye a piece of goods for 45 minutes just under boiling temperature in a bath containing 2 per cent of National Superchrome Red B (National Aniline and Chemical Co.) and 1.5 per cent of acetic acid. Then add 2 per cent of $K_2Cr_2O_7$ and boil for 30 minutes. Remove from the bath and wash thoroughly with water. Wool takes a full red shade while silk is undyed.

BURNING TEST FOR QUALITATIVE IDENTIFICATION OF VEGETABLE AND ANIMAL FIBERS

Burning Test.—The burning test may be employed as a quick means of distinguishing between vegetable and animal fibers. The vegetable fibers when ignited by a flame burn quickly and completely with the well-known odor of vegetable material; while animal fibers such as wool and silk burn more slowly with a distinct odor similar to burning glue and leave a globule of ashy matter. Silk yarn, which has been weighted with mineral salts, when ignited will not be entirely consumed and there will remain a fine mineral filament.

PROCEDURE FOR A COMPLETE QUANTITATIVE ANALYSIS

This procedure is for use in cases where an exhaustive knowledge of the several different fibers present in a sample is desired. In most cases, where not more than two different fibers are present in a sample and their identities are known qualitatively, the proper individual quantitative test may be advantageously applied directly, without first going through the general procedure.

PROCEDURE

Weigh out 2 to 5 g. of the sample in a glass-stoppered weighing bottle and dry at 100 to 110° C. to constant weight. The difference between the initial and final weights represents the moisture content. Boil the dry material thoroughly in dilute HCl (1-per-cent), care being taken not to disintegrate the fibers. If the fibers are much weakened or disintegrated, repeat with a new sample, using a weaker acid. Repeat the boiling with fresh portions of the acid until no residue is found upon evaporating a few drops of the liquid on a watch-glass. This treatment removes mineral loading matter soluble in HCl, finishing materials, more or less dyestuffs, as well as other material soluble in water.

Extract the residue first with alcohol and finally with carbon tetrachloride (CCl_4) until all soluble material is removed. Dry and weigh. Discard the extract. The residue is anhydrous fibers and any matter (mineral) not soluble in HCl. Divide immediately into two parts, and weigh each portion.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, which is generally negligible, and any insoluble salts employed in mordanting or loading.

Heat to boiling about 60 cc. of basic $ZnCl_2$ solution, and immerse the second portion of the fibers. Remove the flame, stir the sample thoroughly for about one minute and again bring to boiling. Transfer immediately to a weighed Gooch crucible using the insoluble fibers as a mat for the crucible. Remove the insoluble fibers to a beaker containing cold, dilute HCl (5-per-cent). Thoroughly wash in the beaker by agitation and again filter. Repeat the process several times, using a weaker acid solution at each subsequent washing. Finally, remove the crucible and finish washing with several portions of hot water until free from chlorine as chloride. Dry at 100 to 105° C. and weigh.

The loss represents silk and in certain cases a portion of the sizing material. Also rayon or artificial silk is here removed.

Treat the residue with about 100 cc. of a solution of approximately 5-per-cent KOH and boil gently for 10 to 15 minutes. Pour into 500 cc. of cold water and let stand until the fibers have settled, and decant carefully the supernatant liquor, taking care to avoid loss of any fibers. Filter through a weighed Gooch crucible and wash thoroughly with boiling water. Moisten with a few cubic centimeters of dilute acetic acid and again wash with hot water, and finally with about 10 cc. of alcohol. Dry and weigh.

The loss in weight represents wool and a small portion of cotton. To correct for this add 3 per cent of the cotton to the cotton figure and subtract the same amount from the wool figure.

The residue is cotton or vegetable fibers (wood fiber, jute, linen, and similar material). Ignite. The loss represents the various vegetable fibers. The residue may consist of asbestos, mineral wool, or other mineral fibers, and should be examined qualitatively and microscopically.

QUANTITATIVE SEPARATIONS OF SAMPLES CONTAINING TWO OR MORE KINDS OF FIBERS

In all of the test procedures described below, all weighings are made on bone-dry material and losses are calculated on the original weight. For all practical purposes, the results so obtained are sufficiently reliable. However, where strictly commercially interpretable results are desired, the procedure must be followed after first correcting the bone-dry percentages to air-dry percentages, assuming the following standard regains at normal atmosphere:

	Standard Regains at Normal Atmosphere, per cent	Normal Regain Factor
Wool	14.0	$\frac{100}{114} = 0.877$
Rayon	11.5	$\frac{100}{111.5} = 0.897$
Silk	11.0	$\frac{100}{111} = 0.900$
Cotton and Cellulose Acetate	6.5	$\frac{100}{106.5} = 0.939$

Example.—A sample shows by analysis on a bone-dry basis:

Cotton	30.0 per cent
Wool	45.0 " "
Silk	25.0 " "
Total	100.0 per cent

Divide these percentages by their respective normal regain factors and obtain values in proportion to the normal atmosphere weights of these materials:

Cotton	$30.0 \div 0.939 = 32.0$
Wool	$45.0 \div 0.877 = 51.3$
Silk	$25.0 \div 0.900 = 27.8$
Total	111.1

By multiplying by $\frac{100}{111.1}$ there is obtained a total percentage of one hundred, and the component percentages are, therefore, the proportions of each fiber present in the material, on a basis of the proper normal regains, as follows:

Cotton	$32.0 \times \frac{100}{111.1} =$	28.8 per cent
Wool	$51.3 \times \frac{100}{111.1} =$	46.2 " "
Silk	$27.8 \times \frac{100}{111.1} =$	25.0 " "
Total	=	**100.0 per cent**

DETERMINATION OF MOISTURE AND SIZE LOSSES

In all of the following quantitative separations the standard procedure for determining the moisture and size losses is as follows and will not be repeated:

Weigh out 2 to 5 g. of the sample in a glass-stoppered bottle and dry at 100 to 110° C. to constant weight. The difference between the initial and final weights represents the moisture content, calculated as a percentage of the original weight. Remove the sizing materials from the residue by boiling with HCl solution (1-per-cent). Wash out the acid with water and dry at 105° C. to get the total weight of the fibers.

COTTON AND WOOL MIXTURES

PRELIMINARY

Weigh out a piece of the goods and dye it in a bath containing 3 per cent of indigo carmine and 2 per cent of acetic acid (both percentages based on the weight of the goods). Dye at boiling temperature for about 15 minutes, washing the goods thoroughly in the bath. The cotton will take a pale blue color and the wool will dye a much deeper blue. By examining the dyed cloth under a hand glass, a good approximation of the amount of wool present may be obtained.

PROCEDURE

Remove the sizing and finishing materials by extracting in ether, boiling in distilled water for 10 minutes, treating in a hot (90 to 95° C.) solution of sodium carbonate (0.5-per-cent) for 30 minutes, rinsing in distilled water, immersing in a hot (85 to 90° C.) solution of HCl (0.5-per-cent) for 30 minutes, rinsing in distilled water, neutralizing in a solution of sodium carbonate (1-per-cent) at room temperature, rinsing thoroughly in distilled water and drying. All weighing shall be made after the specimen has been conditioned at 65 per cent relative humidity, and 70° F. Weighings shall be made to the nearest milligram or equivalent accuracy. Gently boil the specimen in at least 100 times its weight of a solution of potassium hydroxide (5-per-cent) for 10 to 15 minutes. Rinse in hot distilled water, then in a solution of acetic acid (5-per-cent) and again in distilled water. Filter, then dry in air and condition the specimen. The percentage of cotton present shall be calculated from the following formulas:

$$\text{Weight of cotton} = \frac{\text{Weight of residue}}{97} \times 100$$

$$\text{Percentage of cotton} = \frac{\text{Weight of cotton}}{\text{Original weight of specimen}} \times 100$$

COTTON, SILK, AND WOOL MIXTURES

The residue after removal of the sizing material is anhydrous fibers and any mineral matter not soluble in HCl. Divide immediately into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, which is generally negligible, and any insoluble salts employed in mordanting or loading.

Boil the second portion for 2 minutes in a solution of basic $ZnCl_2$ (sp. gr. 1.72), known as Elsner's reagent, which is prepared by dissolving 100 parts of $ZnCl_2$ and four parts of ZnO in 85 parts of hot water to complete solution. Wash the residue in dilute HCl and then in water until the acid has been completely removed as may be detected by litmus paper. The extract contains all the silk. The residue is cotton. Dry and weigh.

When only cotton and silk are present Method A as described under Cotton and Wool Mixtures should be used.

WOOL AND SILK MIXTURES

The residue after removal of the sizing material is anhydrous fibers and any mineral matter not soluble in HCl. Divide immediately into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, and any insoluble salts employed in mordanting or loading.

Dip the second portion in concentrated HCl for two minutes at 49° C. This will dissolve the silk and not materially affect the wool. Wash the residue well until all acid has been removed. Dry and weigh. The extract contains all the silk. The residue is wool.

SILK AND RAYON MIXTURES

Divide the residue after removal of sizing materials into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers and any insoluble salts employed in mordanting or loading.

Treat the second portion at ordinary temperature for 20 minutes in an alkaline solution of copper sulfate known as Lowe's reagent, which is prepared by dissolving 10 g. of $CuSO_4 \cdot 5H_2O$ in 100 cc. of water, adding 5 cc. of glycerin and then adding a 20-per-cent caustic-soda solution until the precipitate formed redissolves. This will dissolve the natural silk, leaving the rayon as an insoluble residue. The extract contains all the silk. The residue is rayon.

ADDITIONAL TESTS FOR SILK AND RAYON MIXTURES

1. When treated with a cold semi-saturated solution of chromic acid silk is slowly soluble; all rayons except the acetate variety are soluble; while cotton and all other vegetable fibers are insoluble.

2. When treated with a 40-per-cent solution of potassium hydroxide, silk is acted upon at 65° C., dissolving at 85° C. and tussah silk swells at 75° C., dissolving at 120° C.; while rayons are insoluble on boiling.

3. In Schweitzer's reagent, silks, collodion and cellulose rayons are soluble, while gelatine rayon stains liquid-bright violet.

Schweitzer's Reagent:

Dissolve 5 g. of copper sulfate in 100 cc. of boiling water, add NaOH solution to complete precipitation; wash the precipitate thoroughly, then dissolve in the least quantity of NH_4OH. This should give a deep blue solution.

4. In Millon's Reagent a brick red color will develop with silk; while rayons remain white or uncolored.

Millon's Reagent:

Dissolve metallic mercury in its own weight of concentrated, c. p. HNO_3 (sp. gr. 1.42), then dilute this solution with an equal volume of water. Sometimes a new preparation of this reagent does not work (perhaps due to the nitric acid used), and so each lot should be tested by moistening scoured wool or real silk with it, gently warming and noting the production of a brick red color on the animal fiber. This reagent, if found reactive, should be kept in a small, tightly-stoppered bottle, when it will usually retain its staining power for a long time. It is used as a stain for animal fibers. The mixed or separated kinds of fibers are covered with a few drops of Millon's Reagent and gently warmed (not boiled).

TUSSAH SILK AND CULTIVATED MIXTURES

Divide the residue after removal of sizing materials into two parts, weighing each.

Reduce the first portion to ash. This will give the natural insoluble ash of the fibers, and any insoluble loading mordants, or tin salts.

Steep the second portion in cold concentrated HCl for 10 minutes, filter and wash the filter well with water until all acid has been removed, dry and reweigh. The extract contains all the silk. The residue is Tussah silk.

DIFFERENTIATION OF RAYONS

Any rayon tested by these methods shall be in the bleached or unbleached state and shall be free from oil or other foreign substances. A suggested procedure for removing the oil or other foreign substances is to rinse the rayon in (*a*) boiling water, (*b*) denatured alcohol, and (*c*) ethyl ether, then allow to dry at room temperature.

TO DISTINGUISH CELLULOSE-ACETATE FROM ALL OTHER RAYONS

Cellulose acetate rayon is distinguished from the regenerated cellulose rayons by its solubility in pure acetone or in glacial acetic acid, if acetone is not available. A small sample of cellulose acetate rayon will dissolve completely in a few minutes; the cellulose rayons are insoluble. The result of this test can be confirmed by twisting the fibers to a tight wad and cautiously applying the flame of a lighted match. Cellulose acetate rayon fuses and burns and hardens at once into a brittle substance, globular in appearance.

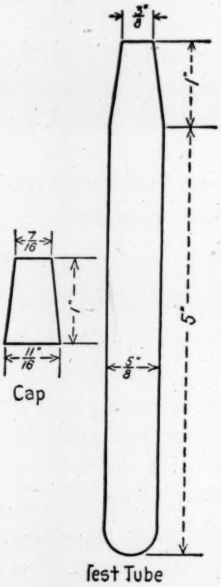

FIG. 1.—Special Test Tube With Cap.

TO DISTINGUISH NITRO-CELLULOSE RAYON FROM VISCOSE AND CUPRAMMONIUM RAYONS

If the rayon is not cellulose acetate, moisten it with a 1-per-cent solution of diphenylamine in a mixture of two parts of concentrated sulfuric acid and one part of glacial acetic acid. (This mixture of acids is recommended instead of sulfuric acid alone as it does not dissolve rayon so quickly and the color persists longer.) Nitrocellulose rayon assumes a deep blue color immediately and the fibers dissolve rapidly to a blue solution. Viscose and cuprammonium rayons are not colored blue and dissolve more slowly.

TO DISTINGUISH VISCOSE RAYON FROM CUPRAMMONIUM RAYON

If the rayon is neither cellulose acetate nor nitro-cellulose rayon, test it for sulfide sulfur. A special test tube with cap of the construction shown in Fig. 1 is convenient for this test in order to protect the test paper from contamination by sulfide in the air.

Introduce 0.5 g. of the rayon into the test tube and add 10 ml. of a 3-per-cent sulfuric acid solution. Place a piece of filter paper, previously soaked in a 10-per-cent lead acetate solution, over the opening of the tube and hold it in position by means of the cap. Immerse the tube to a depth of about 4 in. in a steam bath and heat for 4 hours. If at the end of this period the exposed part of the lead acetate paper becomes stained with a brown or black color (indicating the presence of sulfide sulfur), the sample is viscose rayon. Cuprammonium rayon gives a negative test.

NOTE.—In the opinion of the committee, (1) none of the staining methods thus far proposed can be invariably depended upon to distinguish between viscose and cuprammonium rayon, and (2) no thoroughly reliable method of identifying cuprammonium yarn has been discovered.

TENTATIVE SPECIFICATIONS
FOR
ROUND-HOLE SCREENS FOR TESTING PURPOSES[1]

A.S.T.M. Designation: E 17 – 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

ISSUED, 1931.

Scope. 1. These specifications cover testing screens for use in the classification of materials according to size in all cases where specifications call for use of screens having circular openings.

Plates. 2. Plates used in the manufacture of screens shall be made of brass, bronze, steel or other rigid metal. Thickness of plates shall be governed by size of openings as well as screening area of screens and shall conform to the following requirements:

Screening Area, sq. in.	Size of Opening	Thickness, in.
Under 100	All sizes	0.0500
100 and over	$\frac{1}{16}$ in. to $\frac{1}{8}$ in.	0.0500
	$\frac{1}{8}$ in. to $2\frac{1}{2}$ in.	0.0625
	Over $2\frac{1}{2}$ in.	0.0781

Type of Frame. 3. Frames for laboratory screens 8 in. in diameter shall be of metal at least $2\frac{1}{2}$ in. in height, and sufficiently rigid to resist distortion. Frames for large screens may be of either hardwood or metal and may be square, rectangular or circular, as specified.

Spacing of Opening. 4. (*a*) Spacing of openings for all screens shall conform to the following requirements:

Diameter of Opening, in.	Distance Center to Center of Openings, in.	Diameter of Opening, in.	Distance Center to Center of Openings, in.
$\frac{1}{16}$	$\frac{7}{64}$	1	$1\frac{3}{8}$
$\frac{1}{8}$	$\frac{7}{32}$	$1\frac{1}{4}$	$1\frac{5}{8}$
$\frac{1}{4}$	$\frac{3}{8}$	$1\frac{1}{2}$	2
$\frac{3}{8}$	$\frac{9}{16}$	2	$2\frac{5}{8}$
$\frac{1}{2}$	$\frac{11}{16}$	$2\frac{1}{2}$	$3\frac{1}{4}$
$\frac{5}{8}$	$\frac{13}{16}$	3	$3\frac{3}{4}$
$\frac{3}{4}$	1	$3\frac{1}{2}$	$4\frac{1}{4}$
$\frac{7}{8}$	$1\frac{1}{8}$	4	$4\frac{3}{4}$

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. F. H. Jackson, Chairman of Section on Coarse Screens of Technical Committee III on Size and Shape, of Committee E-1, U. S. Bureau of Public Roads, Washington, D. C.

Arrangement of Openings.

(*b*) The openings in the screen plate shall be so arranged that when spaced according to the requirements of Paragraph (*a*) the maximum number possible is obtained.

Tolerance on Diameter of Openings.

5. (*a*) For screens having openings ¼ in. or less in diameter, the actual diameter of any opening shall not vary from the nominal diameter more than 5 per cent.

(*b*) For screens having openings over ¼ in. in diameter, the actual diameter of any opening shall not vary from the nominal diameter more than 3 per cent.

TENTATIVE METHOD OF BEND TESTING FOR DUCTILITY OF METALS[1]

A.S.T.M. Designation: E 16 - 31 T

This is a **Tentative Standard,** published for the purpose of eliciting criticism and suggestions, and as such is subject to annual revision.

Issued, 1931.[2]

Scope. 1. This method of bend testing consists essentially of bending the specimen by means of forces at the ends and without introducing additional forces at the point of maximum bending. This is followed by measurements of the elongation of the outside fibers at the point of maximum bending. This is known as free bending with measurement of the fiber elongation.

Note.—Although most of the work with this test has been carried out on rolled iron and steel, sufficient work has been done with other forms of ferrous material, as well as with hardened copper alloys and other non-ferrous metals, to show that the principles involved are applicable, although it will be necessary to work out the details in each case. It is obvious that if the specimen bends flat upon itself without fracture no quantitative data in addition to this fact may be obtained. Work on producing failure in such highly ductile materials by special means is under way, and recommendations may be made at a subsequent date. It is equally obvious that if the material is so brittle as to preclude an initial end bend, the test is not applicable. However, there is little need for a bend test if such a condition exists.

TEST SPECIMEN

Preparation of Test Specimens. 2. (*a*) For results in which the measured performance is independent of the thickness of the specimen, rectangular specimens with widths at least three times the thickness shall be used. The edges shall be smoothed so that the fracture will not take place at the edge. A radius up to one-eighth the thickness of the specimen may be used on the edges. The outside surfaces of the specimen shall be smooth and free from local defects and transverse scratches. The length may vary with the thickness of the piece and is unimportant provided it is long enough to perform the bending operation.

(*b*) Round bars may be tested by this method but the results will only be comparative, as for the same material the fiber elongation is found to vary slightly with the diameter.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. F. Moore, Chairman of Technical Committee I, of Committee E-1, on Mechanical Testing, University of Illinois, Urbana, Ill.

[2] Accepted for publication as tentative by Committee E-10 on Standards, August 6, 1931.

Gage Length.

(*c*) The gage length in which the elongation is measured shall be 0.3 in. in the case of plate from $\frac{1}{4}$ to $\frac{1}{2}$ in. in thickness and 1 in. for all plates over $\frac{1}{2}$ in. in thickness. This gage length shall be located at the section of maximum bending and in the center third of the width of the specimen.

NOTE.—Experiments have shown that the gage length is not critical, so that the apparent discontinuity at $\frac{1}{2}$ in. does not lead to errors in excess of the allowable. For certain special applications such as welds it may be desirable to use other gage lengths. In such cases, the gage length used shall be at least equal to the thickness of the plate and not more than twice the thickness of the plate but shall in no case be more than 1 in.

PROCEDURE

Method of Starting the Bend.

3. When starting the bend any local stress or strain at the section which eventually will have the greatest bending should be avoided. This may be accomplished by holding the specimen in a vise about one-third from the end, producing an initial bend at this point by hammer blows, or the specimen may be set up on cross supports and the initial bend started by compression at the third points. The initial bend shall be far enough from the final point of maximum bending so as not to affect it. This shall be performed on both ends of the specimen. The initial bend may vary from 5 to 30 deg., depending on the ductility of the material. The magnitude of this initial bend does not affect the results.

Method of Closing the Bend.

4. (*a*) The specimen with initial bends on each end shall be placed in a vise or press as a strut and compression applied at the ends. The vise or press shall be closed until failure of the outside fibers occurs. The speed is not a factor provided actual shock is avoided. The continuity of closing and the speed may be varied at will without affecting the results beyond the duplicability specified in Section 6.

(*b*) Bending may be carried out in special machines by any other suitable means provided that local stresses at the point of maximum bending are avoided. If such stresses are not avoided low values will result.

Measurement of Fiber Elongation.

5. (*a*) The performance of the specimen in the bend test shall be evaluated by the measurement of the outside fiber elongation. The most direct method of performing this is to measure with a flexible scale the final length between gage marks placed on the specimen before bending, allowance being made for the width of any cracks included in the final gage length.

(*b*) Any other method of measuring the fiber elongation which gives the same values as the direct method described in Paragraph (*a*) may be used. For example, in some cases it may be objectionable to put gage marks on the specimen. In this event the radius of the outside of the specimen may be measured and the elongation calculated. For simplified operation a bend extensometer has been developed, which reads fiber elongation directly when placed on the curved surface. Any such method is satisfactory if, as above stated, the values obtained are consistent with the method of direct measurement.

NOTE.—With material less than ¼ in. in thickness the difficulties in measurement of elongation are so great that the committee is not yet prepared to make any recommendations. The committee is continuing the study of this problem and hopes to make recommendations at a future date.

Duplicability. 6. The duplicability of the test results as obtained by this procedure when applied to rolled steel plate will be within 5 per cent of the fiber elongation. The duplicability of the test when applied to other materials will vary, as the nature of the material will affect the accuracy of the end point determination.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members to the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

A. FERROUS METALS

STANDARD SPECIFICATIONS FOR STEEL TRACK SPIKES

(A.S.T.M. Designation: A 65 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Soft Steel Track Spikes (A 65 – 26 T)"[2] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR SHIPS

(A.S.T.M. Designation: A 12 – 21)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Structural Steel for Ships (A 131 – 31 T)"[3] is intended to replace the present Standard Specifications A 12 and A 13.

STANDARD SPECIFICATIONS FOR RIVET STEEL FOR SHIPS

(A.S.T.M. Designation: A 13 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Structural Steel for Ships (A 131 – 31 T)"[3] is intended to replace the present Standard Specifications A 12 and A 13.

STANDARD SPECIFICATIONS FOR STRUCTURAL SILICON STEEL

(A.S.T.M. Designation: A 94 – 29)[1]

Section 7. (*a*).—In the table following this paragraph after the requirement for elongation in 8-in., insert a requirement for elongation in 2-in., as follows:

Elongation in 2 in., minimum, per cent.............................. $\frac{1\,600\,000}{\text{tens. str.}}$

Section 8.—Letter the present section as Paragraph (*a*) and add a new Paragraph (*b*) to read as follows:

(*b*) For material under $\frac{5}{16}$ in. in thickness or diameter, a deduction from the percentage of elongation in 8 in. specified in Section 7 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. in thickness or diameter below $\frac{5}{16}$ in.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part I, p. 631 (1926); also 1931 Book of A.S.T.M. Tentative Standards, p. 23.

[3] See p. 641.

Section 11 (e).—Change to read as follows by the addition of the italicized words and dimension and the omission of the dimension in brackets:

(*e*) Tension test specimens for material over [1] *1½* in. in thickness or diameter may be machined to a thickness or diameter of at least ¾ in. for a length of at least 9 in. *or they may conform to the dimensions shown in Fig. 2.*

Fig. 2.—Add as Fig. 2 the accompanying Fig. 1.

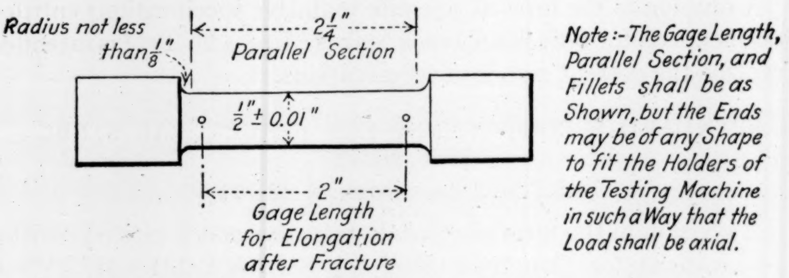
Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture
Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Standard 2-in. Gage Length Tension Test Specimen.

STANDARD SPECIFICATIONS FOR BILLET-STEEL CONCRETE REINFORCEMENT BARS

(A.S.T.M. DESIGNATION: A 15 – 30)[1]

Section 3 (b).—Change to read as follows by the addition of the italicized words:

(*b*) The bars shall be rolled from new billets *of properly identified heats of open-hearth or lots of bessemer steel.* No rerolled material will be accepted.

Section 11 (a).—Change from its present form: namely,

11 (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

11. (*a*) Tension and bend test specimens for plain and deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars as rolled the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece (see Note).

In case it is necessary to determine the tensile or bending properties of the bars without regard to their design, the specimen shall be machined to a uniform cross-section for a length of at least 9 in.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

NOTE.—By this method the area in square inches may be obtained by dividing the weight in pounds per inch of specimen length by 0.2833 (weight of 1 cu. in. of steel); or by dividing the weight in pounds per foot of specimen length by 3.4 (weight of steel 1 in. square, 1 ft. long).

Section 13.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

13. The weight of any lot of bars shall not vary more than 5 per cent [from] *over or under* the theoretical *or specified* weight of that lot. *The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars ⅜ in. and less.*

New Section.—Under a new central heading "Marking," add the following paragraph as a new Section 15, renumbering the present sections accordingly:

15. *Marking.*—The brand of the manufacturer shall be legibly rolled on all deformed bars, and when loaded for mill shipment all bars shall be properly separated and tagged with the manufacturer's test identification number.

STANDARD SPECIFICATIONS FOR RAIL-STEEL CONCRETE REINFORCEMENT BARS

(A.S.T.M. DESIGNATION: A 16 - 14)[1]

Section 7 (a).—Change from its present form: namely,

7. (*a*) Tension and bend test specimens for plain and deformed bars shall be taken from the finished bars, and shall be of the full thickness or diameter of bars as rolled; except that the specimens for deformed bars may be machined for a length of at least 9 in., if deemed necessary by the manufacturer to obtain uniform cross-section.

to read as follows:

7. (*a*) Tension and bend test specimens for plain and deformed bars shall be of the full section of bars as rolled. For tension tests of deformed bars as rolled the sectional area used for unit stress determination shall be calculated from the length and weight of the test piece (see Note).

In case it is necessary to determine the tensile or bending properties of the bars without regard to their design, the specimen shall be machined to a uniform cross-section for a length of at least 9 in.

NOTE.—By this method the area in square inches may be obtained by dividing the weight, in pounds per inch of specimen length, by 0.2833 (weight of 1 cu. in. of steel); or by dividing the weight in pounds per foot of specimen length by 3.4 (weight of steel 1 in. square, 1 ft. long).

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

Section 9.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

9. The weight of any lot of bars shall not vary more than 5 per cent [from] *over or under* the theoretical *or specified* weight of that lot. *The weight of any individual bar shall not vary more than 7.5 per cent over or under the theoretical or specified weight for bars over ⅜ in. in diameter; nor more than 12.5 per cent over or under for bars 3.8 in. and less.*

STANDARD SPECIFICATIONS FOR QUENCHED-AND-TEMPERED CARBON-STEEL AXLES, SHAFTS, AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS

(A.S.T.M. DESIGNATION: A 19 – 27)[1]

Section 5.—Change from its present form: namely,

5. (*a*) Unless otherwise specified by the purchaser, all forgings over 7 in. in diameter shall be bored, and all axles, shafts and similar forgings shall be rough-turned all over. The boring shall be done before quenching.

(*b*) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

to read as follows:

5. (*a*) Unless otherwise specified by the purchaser, all axles, shafts and similar forgings having a minimum diameter over 7 in. shall be bored. The boring shall be done before quenching.

(*b*) In the case of boring, the diameter of the hole, unless otherwise specified, shall be at least 20 per cent of the maximum outside diameter of the forging, exclusive of collars and flanges.

STANDARD SPECIFICATIONS FOR QUENCHED-AND-TEMPERED ALLOY-STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS

(A.S.T.M. DESIGNATION: A 63 – 27)[1]

Section 5.—Make the same change in this section as recommended in Section 5 of Specifications A 19 – 27 above.

STANDARD SPECIFICATIONS FOR STEEL TIE PLATES

(A.S.T.M. DESIGNATION: A 67 – 30)[1]

Section 3 (*a*).—Add the following requirement for copper to the requirements for chemical composition:

Copper, when copper steel is specified, per cent. . . . . .not under 0.20.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshohocken, Pa.

Section 4.—Change the first sentence of Paragraph (*a*) to read as follows by the addition of the italicized words:

4 (*a*) A carbon determination shall be made of each melt of bessemer steel and three analyses every 24 hours representing the average of the elements carbon and phosphorus, ***and also copper when copper steel is specified***, contained in the steel, one for each 8-hour turn respectively.

Change the first sentence of Paragraph (*b*) to read as follows by the addition of the italicized words:

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon and phosphorus; ***also copper when copper steel is specified.***

STANDARD SPECIFICATIONS FOR STEEL PLATES OF STRUCTURAL QUALITY FOR FORGE WELDING

(A.S.T.M. DESIGNATION: A 78 – 30)[1]

Section 3 (b).—Add a reference to the word "nickel" in this section referring to the following footnote:

When these specifications are used for material to be fusion welded, the maximum limit for nickel shall not apply.

STANDARD SPECIFICATIONS FOR STEEL PLATES OF FLANGE QUALITY FOR FORGE WELDING

(A.S.T.M. DESIGNATION: A 89 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Steel Plates of Flange and Firebox Qualities for Forge Welding (A 89 – 31 T)"[2] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR STAYBOLT, ENGINE-BOLT AND EXTRA-REFINED WROUGHT-IRON BARS

(A.S.T.M. DESIGNATION: A 84 – 30)[3]

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Standard Specifications for Staybolt, Engine-Bolt and [Extra-Refined] *Other High-Grade* Wrought-Iron Bars.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. V. H. Lawrence, Secretary of Committee A-1 on Steel, Alan Wood Steel Co., Conshokocken, Pa.

[2] See p. 648.

[3] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-2 on Wrought Iron, Reading Iron Co., 401 N. Broad St., Philadelphia, Pa.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

1. These specifications cover three grades of bar iron:

Grade A.—Staybolt iron, ***round bars only.***
Grade B.—Engine-bolt iron, ***round and hexagon bars only.***
Grade [C] B_1.—[Extra-refined wrought-iron], ***all rectangular*** bars.

Section 2.—In the second paragraph change the words "Grades B and C" to read "Grades B and B_1."

Section 6 (a).—Change the physical properties of the third grade of iron in the table following Paragraph (*a*) to read as follows by the addition of the italicized letter and figures and the omission of those in brackets:

		GRADE [C] B_1
Tensile strength, lb. per sq. in.	1¼ sq. in. or under in sectional area..	48 000 – [54 000] *53 000*
	Over 1¼ sq. in. in sectional area......	[48 000 – 54 000] *47 000 – 53 000*
Yield point, min., lb. per sq. in.	1¼ sq. in. or under in sectional area...	0.6 tens. str.
	Over 1¼ sq. in. to 4 sq. in., incl., in sectional area....................	0.55 tens. str.
	Over 4 sq. in. in sectional area.......	0.5*0* tens. str.
Elongation in 8 in., min., per cent.............		25
Reduction of area, min., per cent..............		[37] *35*

Section 7.—Omit Paragraph (*c*) which reads as follows:

(*c*) *Grade A.*—For flats of all sizes, the minimum reduction of area shall be 40 per cent.

Reletter Paragraph (*d*) as Paragraph (*c*) and change "Grade C" to read "Grade B_1."

Section 8 (a).—In the second paragraph change "Grade B" to read "Grades B and B_1" and omit the third paragraph which reads as follows:

Grade C.—Cold-bend tests will be made only on bars having a nominal section area of 4 sq. in. or under, in which case the test specimen shall stand being bent cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to the thickness of the specimen.

Section 8 (b).—Change "Grades B and C" to read "Grades B and B_1."

Section 9.—In the third paragraph of this section change "Grades B and C" to read "Grades B and B_1."

Section 10 (a).—Change from its present form: namely,

> 10. (*a*) Tension and bend test specimens shall be of the full section of material as rolled, if possible. Otherwise, the specimens shall be machined from the material as rolled; the axis of the specimen shall be located at any point midway between the center and surface of round bars, or midway between the center and edge of flat bars, and shall be parallel to the axis of the bar.

to read as follows:

> 10. (*a*) Tension test specimens for all grades and bend test specimens for Grades A and B shall be of the full section of the material as rolled, if possible; otherwise the specimen shall be machined from the material as rolled. Bend test specimens for Grade B_1 may be reduced by machining to an approximate square, the side of which is equal to the thickness of the original bar. The axes of all specimens shall be parallel to the axis of the bar and shall be located at any point midway between the center and surface of round bars, or midway between the center and edge of flat bars.

Section 12.—In the third paragraph change "Grade C" to read "Grade B_1."

Section 16 (c).—In the second paragraph change "Grades B and C" to read "Grades B and B_1."

STANDARD SPECIFICATIONS FOR CHILLED CAST-IRON WHEELS

(A.S.T.M. DESIGNATION: A 46 - 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Chilled-Tread Cast-Iron Wheels (A 46 - 30 T)"[2] is intended to replace the present standard specifications.

STANDARD METHODS OF TEST FOR MAGNETIC PROPERTIES OF IRON AND STEEL

(A.S.T.M. DESIGNATION: A 34 - 28)[3]

Section 5 (c).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

> (*c*) For permanent magnet steel, the residual induction and coercive force shall be determined from the maximum normal induction corresponding to a magnetizing force of [200] *300* gilberts per cm. unless the maximum permeability is less than 100, in which case the maximum magnetizing force shall be not less than 2½ times the value of the magnetizing force at which this maximum permeability occurs [and shall be some multiple of 200].

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. W. H. Rother, Secretary of Committee A-3 on Cast Iron, 1543 Fillmore Ave., Buffalo, N. Y.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 976 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 112.

[3] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

Sections 14 to 19.—Replace Method C Properties at Low Inductions and Audio Frequencies described in these sections with the following test procedures which include the Owen bridge method and the alternating-current potentiometer method as alternative test procedures:

C. *Alternating-Current Tests at Low Inductions*

14. *Scope.*—These methods provide for the determination of the alternating-current permeability and core loss of magnetic materials at low inductions.

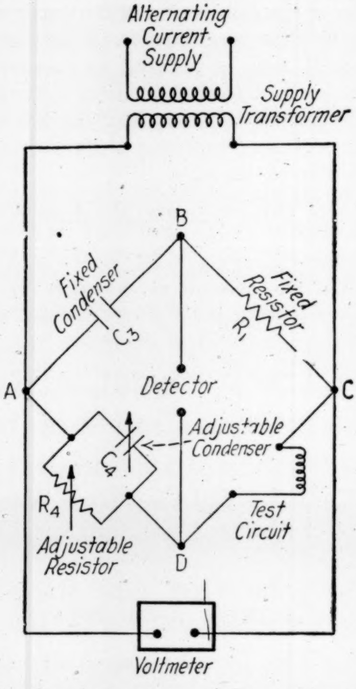
Alternating Current Supply
Supply Transformer
B
Fixed Condenser
C_3
Fixed Resistor
R_1
A
Detector
C
Adjustable Condenser
C_4
R_4
Adjustable Resistor
Test Circuit
D
Voltmeter

FIG. 1.—Diagram Showing Apparatus and Connections for Bridge Method.

These properties are indicative of the effect of the material on the impedance and loss characteristics of apparatus in which the core materials are worked at low inductions.

15. *Standard Values.*—Tests shall be made either at a frequency of 60 cycles per second or at 1000 cycles per second. Standard values at 60 cycles per second are those corresponding to a maximum induction of 10 gausses or 1000 gausses according to the use for which the material is intended. At 1000 cycles per second, the standard values are those corresponding to a maximum induction of 10 gausses.

NOTE.—Apparatus often operates under conditions in which the alternating magnetization is superposed upon a steady unidirectional magnetization, but it is not necessary to introduce this complication into the standard tests, as the relative quality of materials is adequately indicated by the simple alternating-current tests.

TEST SPECIMENS

16. *Test Specimens.*—Test specimens shall consist of not less than 1 kg. (2.2 lb.) of the test material cut with sharp shears into strips 25 cm. ($9\frac{27}{32}$ in.) in length and 3 cm. ($1\frac{3}{16}$ in.) in width, one half parallel and one half at right angles to the direction of rolling, made up into four equal groups, two containing material parallel and two containing material at right angles to the direction of rolling. The four groups shall then be assembled in the test coils to form a square with the corners so arranged that at each corner consecutive layers mutually overlap the butt joints occurring in each single layer. The opposite sides of the square shall consist of material cut in the same manner.

17. *Insulation of Test Specimens.*—When testing for core loss, the separate laminations shall be effectively insulated from each other.

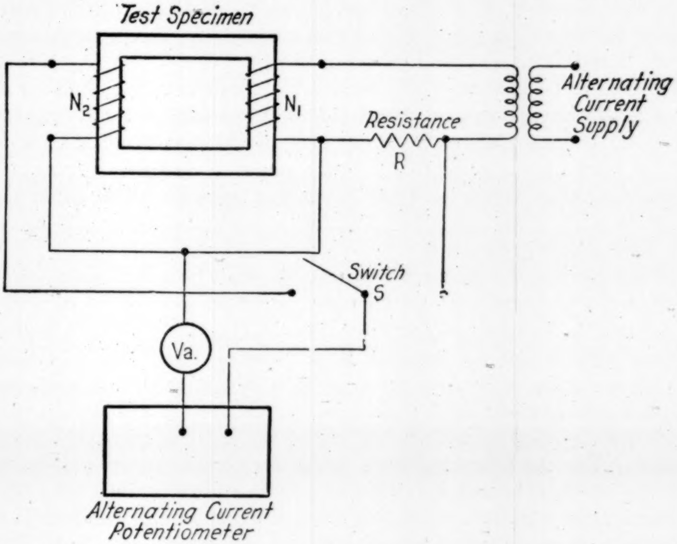

FIG. 2.—Diagram of Connections for Alternating-Current Potentiometer Method.

METHODS OF TEST

18. (*a*) The tests may be made either by the bridge method as shown in Fig. 3 (the accompanying Fig. 1) and specified in Sections 19 and 20 or by the alternating-current potentiometer method as shown in Fig. 4 (the accompanying Fig. 2) and specified in Sections 21 and 22.

(*b*) *Power Supply.*—The supply voltage shall be of approximately a sine wave form, having not more than 10 per cent of total harmonics present.

(*c*) *Test Winding.*—The test winding shall consist of four solenoids surrounding the four sides of the magnetic circuit and connected in series. These solenoids shall be wound on forms of any non-magnetic, non-conducting material of the following dimensions:

Inside cross-section	3.2 by 1 cm.
Thickness of wall	not over 0.3 cm.
Winding length	17 cm.

The winding on each solenoid shall consist of 25 turns of insulated copper wire uniformly wound over the 17-cm. length. The total resistance shall not exceed 0.5 ohm. For the alternating-current potentiometer method, 100 turns shall be uniformly wound on each solenoid and connected in series to form a secondary winding of 400 turns.

Apparatus for Bridge Method:

19. The apparatus shall consist of the following (see accompanying Fig. 1):

(*a*) *Voltmeter.*—Any voltmeter capable of indicating the voltage supplied to the bridge at the test frequency with an accuracy of at least ± 2 per cent may be used. A multi-range vacuum-thermocouple type instrument is recommended.

(*b*) *Fixed Condenser.*—The fixed condenser, C_3, shall be a high grade mica condenser of 1.0 microfarad ± 0.25 per cent capacitance having a power factor of not more than 0.0015 at 1000 cycles per second.

(*c*) *Adjustable Condenser.*—The adjustable condenser, C_4, shall be a four-decade condenser having steps of $10 \times (1.0 + 0.1 + 0.01 + 0.001)$ microfarads adjusted to an accuracy of ± (0.25 per cent + 50 micro-microfarads). The units decade may be made with high-grade paper condensers having a power factor not more than 0.006 at 1000 cycles per second. The other decades shall be made with mica condensers having a power factor of not more than 0.0015 at 1000 cycles per second.

(*d*) *Fixed Resistor.*—The fixed resistor, R_1, shall be a non-reactive resistor of 10 ohms ± 0.1 per cent, with a time constant not to exceed one microsecond.[1]

(*e*) *Adjustable Resistor.*—The adjustable resistor, R_4, shall be a four-decade non-reactive resistor having steps of $10 \times (1000 + 100 + 10 + 1)$ ohms adjusted to an accuracy of ± (0.1 per cent + 0.05 ohms) with a time constant not to exceed one microsecond.[1]

(*f*) *Detector.*—Any zero-current detector having the necessary sensitivity may be used. For the 60-cycle test, a vibration galvanometer is recommended while for the 1000-cycle test a telephone receiver is recommended. A single stage vacuum tube amplifier preceding the galvanometer or receiver is recommended when it is necessary to increase the sensitivity.

(*g*) *Supply Transformer.*—The supply transformer, T, shall be a suitable transformer providing efficient and distortionless inductive coupling and substantial electrostatic isolation between the source of supply and the bridge network.

Procedure for Bridge Test:

20. (*a*) The test specimen shall be thoroughly demagnetized before testing.

(*b*) Set the voltage, E, to give the desired induction in accordance with the relation:

$$E = 0.0707\, AB$$

where B = the maximum induction in gausses, and
A = the cross-sectional area of the specimen in square centimeters calculated from values of length, mass and specific gravity.

---

[1] Time constant is defined as the inductance in henries divided by the resistance in ohms, or the shunt capacitance in farads multiplied by the resistance in ohms.

NOTE.—Values of specific gravity may be assumed in accordance with Section 10(*a*) and (*b*) or may be experimentally determined.

Adjust R_4 and C_4 to balance the bridge. Then:

$$\mu = \frac{7.95\,R_4}{A}$$

and the loss:

$$W = E^2\left[C_4\,\omega^2\,10^{-5} - R_{DC}\left(\frac{1}{R_4^2} + C_4^2\,\omega^2\right)\right]$$

where W = the total loss in watts;
A = the cross-section in square centimeters;
C_4 = the value of adjustable condenser in farads;
ω = 2π times the frequency in cycles per second;
R_{DC} = the resistance of winding in ohms; and
R_4 = the value of adjustable resistance in ohms.

NOTE.—W divided by the mass in kilograms gives the loss in watts per kilogram.

Apparatus for the Potentiometer Method:

21. The apparatus shall consist of the following (see accompanying Fig. 2):

(*a*) *Alternating-Current Potentiometer.*—The alternating-current potentiometer shall be of the coordinate type, indicating voltage in terms of two components having a quadrature phase relation. A suitable phase shifting device shall be provided to adjust the phase of either the potentiometer supply or the magnetizing current.

(*b*) *Resistance.*—The resistance, R, shall be a non-inductive resistance of such a value as to give a potential drop of suitable magnitude. For an induction of 10 gausses, a resistance of 100 ohms is recommended. For an induction of 1000 gausses, a resistance of 1 ohm would be suitable. The resistances should be adjusted to an accuracy of ±0.1 per cent, with a time constant not to exceed one microsecond.

Procedure for Potentiometer Method:

22. (*a*) The test specimen shall be thoroughly demagnetized before testing.

(*b*) Throw the switch, S (accompanying Fig. 2), so as to connect the potentiometer to the secondary winding and adjust the phase so that the total voltage is read on the in-phase dial, the quadrature dial being set to zero. Set the voltage E to give the desired induction in accordance with the relation:

$$E = \sqrt{2}\,\pi f N A B \times 10^{-8}$$

which for 60 cycles per second reduces to:

$$E_{60} = 0.00107\,A\,B$$

and for 1000 cycles per second is:

$$E_{1000} = 0.0178\,A\,B$$

where the symbols have the same significance as in Section 20;
f = frequency in cycles per second, and
N = 400 turns.

Throw switch S to connect the potentiometer to the resistance, R, and read the voltage. The power component is then indicated by the in-phase voltage and the magnetizing component is indicated by the quadrature voltage. The corresponding values of current are obtained by dividing the voltage by the resistance R. Denoting the in-phase and quadrature currents by I_P and I_Q respectively:

$$\mu = 0.563 \frac{B}{I_Q}$$

and

$$W = \frac{E\,I_P}{4}$$

where the symbols have the same significance as in Section 20.

NOTE.—W divided by the mass in kilograms gives the loss in watts per kilogram.

STANDARD DEFINITIONS OF TERMS RELATING TO WROUGHT-IRON SPECIFICATIONS

(A.S.T.M. DESIGNATION: A 81 – 30)[1]

Double Refined Iron.—Change from its present form: namely,

Double Refined Iron.—Iron rolled from a slab pile or box pile of refined iron bars, all bars running the full length of the pile.

to read as follows:

Double-Refined Iron.—Iron to be classed as double refined, shall be all new wrought iron,[a] which shall be first rolled into muck bars. These bars shall then be twice piled and rerolled. All iron shall be free from steel and from foreign scrap. The manufacturer may use his own mill products of at least equal quality, but only in the first piling. In the final piling all bars shall be of the full length of the pile.

[a] Wrought Iron is defined as follows in the Standard Definitions of Terms Relating to Wrought-Iron Specifications (A.S.T.M. Designation: A 81) of the American Society for Testing Materials:

Wrought Iron.—A ferrous material, aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which, without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag.

B. NON-FERROUS METALS

STANDARD SPECIFICATIONS FOR BRONZE BEARING METAL IN INGOT FORM

(A.S.T.M. DESIGNATION: B 31 – 21)[2]

***Section 3.*—Replace the present table of requirements for chemical composition with the following:**

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-2 on Wrought Iron, Reading Iron Co., 401 N. Broad St., Philadelphia, Pa.

[2] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

Alloy, Grade No.	Copper, per cent	Tin, per cent	Lead, per cent	Phosphorus, per cent	Impurities, maximum, per cent						Constituents Other than Copper, Tin, Lead and Phosphorus, per cent
					Zinc	Iron	Nickel	Antimony	Aluminum	Sulfur	
1........	85	10	5	0.70[a]	0.25	0.25	0.25	0.75	none	0.05	0.50 - 1.00
2........	80	10	10	0.70[a]	0.50	0.25	0.25	0.75	none	0.05	0.75 - 1.25
3........	80	10	10	0.05[b]	2.00	0.25	0.25	0.75	none	0.05	2.50 - 3.00
4........	77	8	15	0.25[b]	0.50	0.25	0.25	0.75	none	0.05	0.75 - 1.25
5........	73	7	20	0.05[b]	0.50	0.25	0.25	0.75	none	0.05	1.00 - 1.25
6........	70	5	25	none	0.50	0.25	0.25	0.75	none	0.05	1.00 - 1.25

[a] Minimum. [b] Maximum.

Section 4.—In the table of permissible variations for the percentage of elements specified over 10 per cent, change the permissible variations over and under the specified value from "1.50 per cent" to "2.00 per cent."

STANDARD SPECIFICATIONS FOR SEAMLESS ADMIRALTY CONDENSER TUBES AND FERRULE STOCK

(A.S.T.M. DESIGNATION: B 44 - 29)[1]

Section 14.—Change from its present form: namely,

14. The length shall not be less but may be $\frac{1}{16}$ in. more than that ordered when measured at a temperature of 20° C. (68° F.).

to read as follows:

14. The length shall not be less than that ordered when measured at a temperature of 20° C. (68° F.), but may be more than that ordered by the amounts in the following table:

ORDERED LENGTH, FT.	PERMISSIBLE TOLERANCES
Up to 15, inclusive..................................	$+\frac{1}{16}$
Over 15 to 20, inclusive..	$+\frac{3}{32}$
Over 20..	$+\frac{1}{8}$

STANDARD SPECIFICATIONS FOR SEAMLESS 70-30 BRASS CONDENSER TUBES AND FERRULE STOCK

(A.S.T.M. DESIGNATION: B 55 - 25)[1]

Section 14.—Make the same change in this section as recommended in Section 14 of Specifications B 44 - 29 above.

STANDARD SPECIFICATIONS FOR SEAMLESS MUNTZ METAL CONDENSER TUBES AND FERRULE STOCK

(A.S.T.M. DESIGNATION: B 56 - 25)[1]

Section 14.—Make the same change in this section as recommended in Section 14 of Specifications B 44 - 29 above.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. D. K. Crampton, Secretary of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, Chase Brass and Copper Co., Inc., Waterbury, Conn.

STANDARD METHODS OF CHEMICAL ANALYSIS OF MANGANESE BRONZE

(A.S.T.M. DESIGNATION: B 27 – 19)[1]

Under the Determination of Manganese by the Persulfate Method, change the description under Method from its present form: namely,

> In a 250-cc. Erlenmeyer flask dissolve 1 g. of bronze in 24 cc. of the "solution for dissolving." Allow to stand on a steam bath or hot plate until entirely dissolved, and until the oxides of nitrogen are expelled. Add 15 cc. of $AgNO_3$ solution and 20 cc. of ammonium persulfate and leave on the steam bath until the solution has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C. in running water, and add 50 cc. of cold water. Titrate with standard sodium-arsenite solution to the disappearance of the pink color.

to read as follows:

> Adjust the size of sample to the expected percentage so that the portion taken does not contain more than 0.002 g. manganese. Place it in a 250-cc. Erlenmeyer flask with 24 cc. of the "solution for dissolving" and heat until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling-hot water, add 20 cc. of $AgNO_3$ solution and 30 cc. of the persulfate solution, then remove to a moderately warm place to stand for a few minutes for complete development of the permanganic acid. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

C. CEMENT, LIME, GYPSUM AND CLAY PRODUCTS

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT

(A.S.T.M. DESIGNATION: C 9 – 30)[2]

A revision in the form of a separate tentative standard entitled "Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 – 16 T)"[3] is intended to become a part of the present standard specifications.

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[1] 1930 Book of A.S.T.M. Standards, Part I. Criticisms of this revision are solicited and should be directed to Mr. E. E. Thum, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, *Metal Progress*, 7016 Euclid Ave., Cleveland, Ohio.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. P. H. Bates, Chairman of Committee C-1 on Cement, U. S. Bureau of Standards, Washington, D. C.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1931 Book of A.S.T.M. Tentative Standards, p. 220.

STANDARD SPECIFICATIONS FOR HYDRATED LIME FOR STRUCTURAL PURPOSES

(A.S.T.M. DESIGNATION: C 6-31)[1]

Section 12.—Change the second and fifth paragraphs from their present form: namely,

> The lime shall be made into a stiff putty with water and permitted to soak over night. It shall be molded in a ring such as is used with a Vicat needle, resting the specimen on a glass plate.
>
> If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

to read respectively as follows:

> The lime shall be made into a stiff putty with water, stirred vigorously with a trowel or spatula for three minutes and permitted to soak over night. It shall be stirred vigorously with a trowel or spatula for three minutes, molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate.
>
> If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, stirred vigorously with a trowel or spatula for three minutes, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared.

Section 13.—Change the first paragraph to read as follows by the addition of the italicized words:

> 13. Plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows: Three hundred grams of the sample shall be mixed with enough water to form a thick putty *and stirred vigorously for 3 minutes with a trowel or spatula*. After aging in a vessel covered with a damp cloth for not less than 16 nor more than 24 hours, this putty shall be *stirred vigorously for 3 minutes with a trowel or spatula and* adjusted to standard consistency, as defined in Section 12, with a permissible variation of ±5 mm.

STANDARD SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE

(A.S.T.M. DESIGNATION: C 14-24)[2]

Section 1.—Add the following footnote:

Caution.—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction.

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. V. Brumbaugh, Secretary of Committee C-7 on Lime, 927 Fifteenth St., N. W., Washington, D. C.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. E. S. Rankin, Secretary of Committee C-4 on Clay and Concrete Pipe, Bureau of Sewers, City Hall, Newark, N. J.

STANDARD SPECIFICATIONS FOR GYPSUM WALL BOARD

(A.S.T.M. DESIGNATION: C 36 – 25)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Gypsum Wall Board (C 36 – 31 T)"[2] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR GYPSUM PLASTER BOARD

(A.S.T.M. DESIGNATION: C 37 – 30)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Gypsum Lath (C 37 – 31 T)"[3] is intended to replace the present standard specifications.

STANDARD METHOD OF TEST FOR POROSITY AND PERMANENT VOLUME CHANGES IN REFRACTORY MATERIALS

(A.S.T.M. DESIGNATION: C 20 – 20)[4]

Section 5.—Change Paragraphs (*c*), (*d*), (*e*), (*f*), (*g*), and (*h*) from their present form: namely,

(*c*) The test specimens shall be placed in kerosine of known density (δ) under a vacuum of 24 in. for 4 hours at 25° C. and cooled to room temperature while yet immersed.

(*d*) When cool, each test specimen shall be weighed suspended in kerosine at 25° C. to determine its *Suspended Weight* (S), in grams.

(*e*) The *Saturated Weight* (W), in grams, of each test specimen shall be obtained immediately after obtaining the suspended weight, by drying lightly with a kerosine-moistened towel to remove the excess kerosine and then weighing in air.

(*f*) The *Exterior Volume* (V), in cubic centimeters, of each test specimen is obtained by subtracting the suspended weight (S) from the saturated weight (W), and dividing by the density (δ) of the kerosine. Thus:

$$V = \frac{W - S}{\delta} \quad \ldots\ldots (1)$$

(*g*) The *Actual Volume of Open Pores* (V_1) in cubic centimeters, is obtained by subtracting the dry weight (D) from the saturated weight (W), and dividing by the density (δ) of the kerosine. Thus:

$$V_1 = \frac{W - D}{\delta} \quad \ldots\ldots (2)$$

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill.

[2] See p. 740.

[3] See p. 743.

[4] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, Box 935, Baltimore, Md.

(*h*) The *Apparent Specific Gravity* (T_1) of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights, and multiplying by the density of the kerosine. Thus:

$$T_1 = \frac{D}{D - S}\delta \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

to read as follows:

(*c*) The test specimens shall be placed in distilled water and boiled for 2 hours and then allowed to cool to room temperature while still immersed in water. During boiling, the test specimens shall not be in contact with the heated bottom of the container.

(*d*) *Weight Suspended in Water.*—Each test specimen shall be weighed while suspended in water to the nearest 0.10 g. to determine its suspended weight, S, in grams.

(*e*) *Saturated Weight.*—The saturated weight, W, in grams of each test specimen shall be obtained immediately after obtaining the suspended weight, S, by blotting lightly with a moistened towel to remove the excess water and then weighing in air to the nearest 0.10 g.

(*f*) *Exterior Volume.*—The exterior volume, V, in cubic centimeters of each test specimen is obtained by subtracting the suspended weight, S, from the saturated weight, W.

(*g*) *Actual Volume of Open Pores.*—The actual volume of open pores, V_1, in cubic centimeters is obtained by subtracting the dry weight, D, from the saturated weight, W.

(*h*) *Apparent Specific Gravity.*—The apparent specific gravity, T_1, of that portion of the test specimen which is impervious to liquid is obtained by dividing the dry weight by the difference between the dry and suspended weights as follows:

$$T_1 = \frac{D}{D - S}$$

In the formulas which appear in Paragraphs (*j*) and (*k*) omit the function "δ" for the density of kerosine.

New Paragraph.—Add the following new Paragraph (*l*) to Section 5:

(*l*) *Water Absorption.*—The water absorption, A, in per cent is obtained by dividing the weight of the water absorbed, in grams, by the weight of the dry test specimens in grams and multiplying by 100 as follows:

$$A = \frac{W - D}{D} \times 100$$

STANDARD METHOD OF TEST FOR SOFTENING POINT OF FIRE-CLAY BRICK

(A.S.T.M. DESIGNATION: C 24 - 31)[1]

Title.—Change the title of this method to read as follows, by the addition of the italicized words and the omission of those in brackets:

> Standard Method of Test for [Softening Point] ***Determining the Pyrometric Cone Equivalent*** of Fire-Clay ***and Fire*** Brick.

Section 1.—Change the scope of this method from its present form: namely,

> 1. The object of this test is to determine the softening point of fire-clay brick, by comparison of test cones with standard Orton pyrometric cones heated in a suitable furnace.

to read as follows:

> 1. This method is intended for determining the pyrometric cone equivalent of fire clay, fire brick, silica cement and ground fire clay by comparison of test cones with standard Orton pyrometric cones under the conditions herein prescribed.

Section 2.—Change the description of the preparation of sample from its present form: namely,

> 2. A 1-kg. (2-lb.) sample shall be taken by chipping off approximately equal portions from the corners of the brick. These fragments shall be reduced in size by means of rolls or a jaw crusher adjusted to pass a lump 6 mm. (¼ in.) in diameter. They shall be mixed thoroughly, and the amount of material reduced to about 250 g. (0.5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall be ground in a porcelain or agate mortar to pass a No. 60 sieve of the U. S. Standard Sieve Series. In order to avoid excessive reduction of the fines, they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

to read as follows:

> 2. (*a*) *Lump Clay or Brick.*—The entire sample of lump clay or brick, in case the amount is small, shall be reduced in size by means of rolls or a jaw crusher to a maximum size of ¼ in. In case the amount is large, a representative sample obtained by approved methods shall be so treated. The sample shall then be mixed thoroughly and the amount reduced to about 250 g. (0.5 lb.) by quartering. A magnet shall be repeatedly passed through the crushed material until all particles of metallic iron are removed. This portion shall then be ground in an agate, porcelain, or hard steel mortar and the amount reduced again by quartering. The final size of the sample shall be 50 g. and the fineness such

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[1] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, Box 935, Baltimore, Md.

that it will pass a No. 65 sieve, the diameter of wire being 0.183 mm. (0.0072 in.) and the screen openings being 0.208 mm. (0.0082 in.). In order to avoid excessive reduction of fines they shall be removed frequently during the process of reduction by throwing the sample on the sieve and continuing the grinding of the coarser particles until all the sample will pass through the sieve.

(*b*) In the case of ground fire clay and silica cements, the sample obtained by approved methods shall be tested as received without grinding or other treatment.

The addition of the following Note after Section 2 is recommended since it is felt necessary to avoid the use of the P. C. E. test on refractory cements containing added fluxes, which is at present a subject of study.

NOTE.—For the purpose of this test, silica cement is understood to be the usual mixture of ground ganister and fire clay with no added fluxes. By ground fire clay is understood the usual mixture of ground raw fire clay, calcined clay, or burnt brick with no added fluxes. Neither includes the materials sold under the name of high-temperature cements.

Section 3 (*a*).—Change the description of the test cones from its present form: namely,

3. (*c*) The sample thus prepared shall be thoroughly mixed and, after the addition of sufficient dextrine or glue and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons measuring 5 mm. ($\frac{3}{16}$ in.) on the sides at the base and 25 mm. (1 in.) high.

to read as follows:

3. (*a*) The dried sample shall be thoroughly mixed and after the addition of sufficient dextrine, glue, gum tragacanth or other alkali-free organic binder and water, shall be formed into test cones in a metal mold in the shape of tetrahedrons 8 mm. ($\frac{5}{16}$ in.) on the sides at the base and 25 mm. (1 in.) in height.

Appendix.—Add the following cone temperature table as Appendix to these methods:

The temperature corresponding with the end points of those standard Orton pyrometric cones, which are used in connection with refractories, are as follows:

	End Point			End Point	
Cone	Deg. Cent.	Deg. Fahr.	Cone	Deg. Cent.	Deg. Fahr.
No. 15	1435	2615	No. 29	1640	2984
No. 16	1465	2669	No. 30	1650	3002
No. 17	1475	2687	No. 31	1680	3056
No. 18	1490	2714	No. 32	1700	3092
No. 19	1520	2768	No. 33	1745	3173
No. 20	1530	2786	No. 34	1760	3200
No. 23	1580	2876	No. 35	1785	3245
No. 26	1595	2903	No. 36	1810	3290
No. 27	1605	2921	No. 37	1820	3308
No. 28	1615	2939	No. 38	1835	3335

NOTE.—These temperatures, which were determined by Fairchild and Peters[a] for a heating rate of 150° C. per hour for cones Nos. 15 to 20, and of 100° C. per hour for cones Nos. 23 to 38, other conditions being the same as specified, apply satisfactorily for all the conditions of this test method, but do not apply to conditions of the commercial firing and use of refractory materials.

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[a] Fairchild and Peters, "Characteristics of Pyrometric Cones," *Journal*, Am. Ceramic Soc., Vol. 9, No. 11, p. 700, November, 1926.

STANDARD METHODS OF TESTING GYPSUM AND GYPSUM PRODUCTS

(A.S.T.M. DESIGNATION: C 26 – 30)[1]

Section 27.—Change this section from its present form: namely,

27. ***Flexural Strength of Gypsum Boards.***—(*a*) Test specimens shall be taken from not less than ten gypsum boards.

(*b*) Flexural strength test specimens shall be 12 in. (300 mm.) in width and approximately 18 in. (460 mm.) in length. They shall be supported on fixed parallel bearings spaced 16 in. (410 mm.) on centers, and shall be loaded through a similar bearing midway between the supports. All bearing and load surfaces shall be true, shall engage the full width of the test specimen, and shall be rounded to a radius of ⅛ in. (3.2 mm.).

(*c*) Test loads shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ±10 per cent in the rate. Strength test results shall be reported when the load is applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

NOTE.—In testing gypsum boards of such narrow width that the longest dimension of the standard test specimen cannot be cut across the fiber of the surfacing, the strength test with knife edges parallel to the fiber of the surfacing may be omitted.

to read as follows:

27. (*a*) ***Test Specimens.***—The test specimens shall be 12 in. (300 mm.) in width and approximately 16 in. (410 mm.) in length. The specimens shall be weighed to within 0.5 g. and then stored at a temperature of from 60 to 85° F. in an atmosphere of 25 to 50-per-cent relative humidity. The specimens shall be weighed once a day until the weight has become constant to within 0.1 per cent.

(*b*) ***Procedure.***—The test specimen shall be centrally supported on fixed parallel bearings spaced 14 in. (350 mm.) between centers and the load-applying block brought in contact with the upper surface of the specimen midway between the supports. All bearings and load surfaces shall be true, shall engage the full width of the test specimen and shall be rounded to a radius of ⅛ in. (3.2 mm.). The test load shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate.

(*c*) ***Report.***—Flexural strength test results shall be reported with the load applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill.

NOTE.—In testing gypsum boards of such narrow width that the longest dimension of the standard test specimen cannot be cut across the fiber of the surfacing, the strength test with knife edges parallel to the fiber of the surfacing may be omitted.

STANDARD DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY

(A.S.T.M. DESIGNATION: C 11 - 28)[1]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 31 T)"[2] are intended to be added to the present standard definitions.

STANDARD DEFINITION OF THE TERM SAND

(A.S.T.M. DESIGNATION: C 58 - 28)[3]

The Tentative Definition of the Term Aggregate (C 58 - 28 T)[4] is intended to be included, when adopted, with the present Standard Definition of the Term Sand.

STANDARD DEFINITIONS OF TERMS RELATING TO REFRACTORIES

(A.S.T.M. DESIGNATION: C 71 - 31)[5]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Heat Transmission of Refractories (C 71 - 31 T)"[6] are intended to be added to the present standard definitions.

D. MISCELLANEOUS MATERIALS

STANDARD SPECIFICATIONS FOR BROKEN SLAG FOR WATERBOUND BASE AND WEARING COURSE

(A.S.T.M. DESIGNATION: D 65 - 23)[7]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 12.0 per cent.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, Gypsum Assn., 211 W. Wacker Drive, Chicago, Ill.

[2] See p. 749.

[3] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. E. Hess, Secretary of Committee E-8 on Nomenclature and Definitions, 1315 Spruce St., Philadelphia, Pa.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part I, p. 1125 (1928); also 1931 Book of A.S.T.M. Tentative Standards, p. 271.

[5] 1931 Supplement to Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, Box 935, Baltimore, Md.

[6] See p. 779.

[7] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

[Retained on] *Passing* 2½-in. screen . . . not [less] *more* than [85] *15* per cent.

Section 7 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

STANDARD SPECIFICATIONS FOR SHOVEL-RUN OR CRUSHER-RUN BROKEN SLAG FOR WATERBOUND BASE

(A.S.T.M. DESIGNATION: D 66 – 23)[1]

Section 4.—Omit this section, reading as follows, renumbering the subsequent sections accordingly:

4. The percentage of wear shall be not more than 15.0 per cent.

Section 6 (b).—Omit this paragraph which refers to the method for determining the percentage of wear.

STANDARD SPECIFICATIONS FOR BLOCK FOR GRANITE BLOCK PAVEMENTS

(A.S.T.M. DESIGNATION: D 59 – 26)[1]

Section 3 (a).—Change to read as follows by the addition of the italicized words:

3. (*a*) The percentage of wear and the French coefficient of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Rock (A.S.T.M. Designation: D 2) of the American Society for Testing Materials, *except that the sample shall be prepared by use of a press and the fragments shall be as uniform and as nearly cubical as practicable.*

STANDARD SPECIFICATIONS FOR BLOCK FOR RECUT GRANITE BLOCK PAVEMENTS

(A.S.T.M. DESIGNATION: D 131 – 23)[1]

Section 3 (a).—Make the same change as in Section 3 (*a*) of Specifications D 59 – 26 above.

STANDARD SPECIFICATIONS FOR BLOCK FOR DURAX GRANITE PAVEMENTS

(A.S.T.M. DESIGNATION: D 132 – 23)[1]

Section 3 (a).—Make the same change as in Section 3 (*a*) of Specifications D 59 – 26 above.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 801 Second Ave., New York City.

STANDARD SPECIFICATIONS FOR TEXTILE TESTING MACHINES

(A.S.T.M. DESIGNATION: D 76 - 27)[1]

Section 5 (*a*) *Fabric Jaws.*—Add a new paragraph to read as follows:

> In the case of vertical or upright testing machines, where the upper jaws are not held in positive alignment, it is recommended that the lower jaw of the testing machine be provided with two tapered pins one on each side about ½ in. in diameter which project upward and are adjustable for different spacing between the top and bottom jaws. The upper ends of these pins shall fit into the tapered holes in the upper jaw when placing the specimen but disengaging when the jaws separate. In this way they regulate the distance between the jaws and hold them in positive alignment while the test specimen is being inserted.

STANDARD SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR ELECTRICAL SILK AND COTTON TAPES

(A.S.T.M. DESIGNATION: D 259 - 27)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Tolerances and Test Methods for Silk and Cotton Tapes (D 259 - 31 T)"[2] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR TOLERANCES AND TEST METHODS FOR CERTAIN LIGHT AND MEDIUM COTTON FABRICS

(A.S.T.M. DESIGNATION: D 274 - 29)[1]

New Section.—Add the following new test procedure as Section 8:

> ### TEAR RESISTANCE
>
> 8. (*a*) *Preferred Method.*—A specimen 3 in. in width and 8 in. in length shall be selected for test. A longitudinal cut 3 in. in length shall be made in the center of the specimen. One of the tongues thus formed shall be placed in the upper jaw of a tensile strength testing machine, preferably with automatic recording device, and the other in the lower jaw. The machine shall then be started and the specimen torn, the speed of the pulling jaw being 12 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered to be the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

[2] See p. 990.

(*b*) *Alternate Method.*—A specimen 3 in. in width and 6 in. in length shall be selected for test. An isosceles trapezoid having an altitude of 3 in. and with bases 1 in. and 4 in. in length, respectively, shall then be marked on the specimen with the aid of a template. A cut ¼ to ⅜ in. in length shall then be made in the center of the 1-in. length and perpendicular to it. The specimen shall then be clamped in the jaws of the tensile strength testing machine along the nonparallel sides of the trapezoid. The initial distance between the jaws shall be 1 in., and the width of the jaws shall be 3 in. or more. One edge of the specimen shall thus be held taut while the other edge lies in folds. The machine shall then be started and the sample torn, the speed of the pulling jaw being 3 in. per minute. The pawl on the pendulum shall be disengaged from the ratchet during the test. The average load necessary to continue the tear after it has been started shall be considered as the tear resistance of the fabric. The average of five determinations in the warp and five in the filling directions shall be reported. The capacity of the machine should be such that the specimen tears in the range of maximum sensitivity.

STANDARD GENERAL METHODS OF TESTING WOVEN TEXTILE FABRICS

(A.S.T.M. DESIGNATION: D 39 – 27)[1]

New Section.—Add as a new Section 14 the tear resistance test procedure recommended in Specifications D 274 – 29 above.

STANDARD METHODS OF TEST FOR VISCOSITY OF PETROLEUM PRODUCTS AND LUBRICANTS

(A.S.T.M. DESIGNATION: D 88 – 30)[2]

Section 3 (*b*).—Change to read as follows by the addition of the italicized figures:

(*b*) With the Saybolt Furol Viscosimeter, determinations shall be made at 77, *100*, 122, or 212° F. (25, *37.8*, 50 or 100° C.).

STANDARD METHODS OF TEST FOR DISTILLATION OF NATURAL GAS GASOLINE

(A.S.T.M. DESIGNATION: D 216 – 30)[2]

Section 9.—Insert a new Paragraph (*d*) to read as follows and reletter the present Paragraphs (*d*), (*e*), and (*f*), accordingly:

(*d*) A record shall be be made of the room temperature at the time of each distillation. The heating apparatus including the shield and flask support shall be at room temperature at the start of each distillation.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. R. P. Anderson, American Petroleum Inst., 250 Park Ave., New York City.

At the end of the relettered Paragraph (*e*) add the following sentence:

> The thermometer shall be approximately at room temperature when placed in the flask.

In the relettered Paragraph (*g*) change the third sentence to read as follows by the addition of the italicized words and the omission of the word in brackets:

> The top of the graduate shall be covered closely during the distillation with a piece of blotting paper, or its equivalent, [and] *so* cut *as* to fit the condenser tube tightly.

Section 10.—Change the first sentence of this section to read as follows by the addition of the italicized word:

> When everything is in readiness, heat shall be applied *immediately* at a uniform rate, so regulated that the first drop of the condensate falls from the condenser in not less than two nor more than five minutes.

Change the third paragraph of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> The heating shall be continued until the mercury reaches a maximum and starts to fall consistently *after the bottom of the flask has become dry.* The highest temperature observed on the distillation thermometer shall be recorded as the *maximum temperature or* end point. [Usually this point will be reached after the bottom of the flask has become dry. If the bottom of the flask is not dry, the operator should note this on the report.]

Section 13.—Omit this section which reads as follows:

> 13. The form shown in Fig. 3 is suggested for the recording of results of tests of natural gas gasoline.

Figure 3.—Omit this figure which shows the form for recording test results.

STANDARD METHODS OF SAMPLING AND ANALYSIS OF CREOSOTE OIL

(A.S.T.M. DESIGNATION: D 38 – 30)[1]

Section 4.—Change the last sentence of the first paragraph to read as follows by the addition of the italicized figure and the omission of the words and figure in brackets:

> If more than [2] *3* per cent of water is present, [or if the water is apparently present to an extent in excess of 2 per cent, but an accurate separation is impossible,] the percentage of water present shall be determined by the following method, and the water-free oil so obtained shall be used in the distillation test:

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

Section 9.—Replace the second and third sentences: namely,

> In case the oil requires to be brought to a higher temperature than 38° C. in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by adding 0.0008 to the observed specific gravity for each degree Centigrade above 38° C. at which the test is made. This correction factor does not apply with equal accuracy to all oils, but serious error due to its use will be avoided if the foregoing precaution is observed, with respect to avoiding unnecessarily high temperature.

by a single sentence reading as follows:

> In case it is necessary to bring the oil to a higher temperature than 38° C. in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by selecting the appropriate factor from Tables I and II shown in the appendix.

Add as an Appendix to these methods the accompanying Tables I and II giving factors for use in correcting the volume of creosote oil from observed temperatures to 100° F. Precede the tables with the following introductory paragraph:

> The accompanying Tables I and II were prepared by the U. S. Bureau of Standards to meet the demand of the users and producers of creosote oil for accurate correction factors. The tables have been adopted as standard by the American Wood Preservers' Association and are being considered for adoption by the American Railway Engineering Association; they are the outcome of a Joint Conference Committee representing these associations and the American Society for Testing Materials. Special attention is directed to the importance of the note of warning with regard to measurement of oil at temperatures below 100° F.

New Test Procedure.—The Tentative Method for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions (D 38 – 30 T)[1] is intended to be included, when adopted, in the present Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 30).

STANDARD METHOD OF TEST FOR DISTILLATION OF CREOSOTE OIL

(A.S.T.M. DESIGNATION: D 246 – 30)[2]

Section 8.—Change the phase "If the presence of water is suspected or known" to read "If the presence of 3 per cent of water is suspected or known."

Section 10.—Add a new paragraph to read as follows:

> (*f*) If the fraction 0 to 210° C. contains water the amount of water shall be determined. This amount shall then be deducted from the weight of oil taken and all of the fractions shall be corrected to a percentage based on dry oil. A convenient method for determining the amount of water is to transfer this fraction, after weighing, to a tube or cylinder graduated in 0.1 cc. and add benzol. This almost always causes a clear separation between the oil and water.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part I, p. 1152 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 550.

[2] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

TABLE I.—FACTORS TO BE USED FOR CORRECTING THE SPECIFIC GRAVITY OF CREOSOTE OIL TO 100° F. WHEN THE OIL IS AT TEMPERATURES RANGING FROM 60 TO 220° F.

GROUP I.—For Distillate Creosote Including Distillate Water-Gas-Tar Creosote, Having a Specific Gravity at 100°/60° F. (37.8°/15.56° C.) Below 1.0900.

GROUP II.—For High-Boiling Distillate Creosote or Anthracene Oils Having a Specific Gravity at 100°/60° F. (37.8°/15.56° C.) Above 1.0900.

Observed Temperature, deg. Fahr.	Correction Factor to be Added to Observed Specific Gravity		Observed Temperature, deg. Fahr.	Correction Factor to be Added to Observed Specific Gravity		Observed Temperature, deg. Fahr.	Correction Factor to be Added to Observed Specific Gravity	
	Group I	Group II		Group I	Group II		Group I	Group II
220	0.0491	0.0468	180	0.0326	0.0312	140	0.0161	0.0156
219	0.0487	0.0464	179	0.0322	0.0308	139	0.0157	0.0152
218	0.0483	0.0460	178	0.0318	0.0304	138	0.0153	0.0148
217	0.0479	0.0457	177	0.0314	0.0301	137	0.0149	0.0144
216	0.0475	0.0453	176	0.0309	0.0297	136	0.0145	0.0140
215	0.0471	0.0449	175	0.0305	0.0293	135	0.0141	0.0136
214	0.0467	0.0445	174	0.0301	0.0289	134	0.0137	0.0132
213	0.0462	0.0441	173	0.0297	0.0285	133	0.0133	0.0128
212	0.0458	0.0437	172	0.0293	0 0281	132	0.0129	0.0124
211	0.0454	0.0433	171	0.0289	0.0277	131	0.0125	0.0120
210	0.0450	0.0429	170	0.0284	0.0273	130	0.0121	0.0117
209	0.0446	0.0425	169	0.0280	0.0269	129	0.0117	0.0113
208	0.0442	0.0421	168	0.0276	0.0265	128	0.0113	0.0109
207	0.0438	0.0418	167	0.0272	0.0261	127	0.0109	0.0105
206	0.0434	0.0414	166	0.0268	0.0257	126	0.0105	0.0101
205	0.0430	0.0410	165	0.0264	0.0253	125	0.0101	0.0097
204	0.0426	0.0406	164	0.0260	0.0250	124	0.0097	0.0093
203	0.0422	0.0402	163	0.0256	0.0246	123	0.0093	0.0089
202	0.0418	0.0398	162	0.0252	0.0242	122	0.0089	0.0085
201	0.0413	0.0394	161	0.0248	0.0238	121	0.0084	0.0081
200	0.0409	0.0390	160	0.0244	0.0234	120	0.0080	0.0078
199	0.0405	0.0386	159	0.0239	0.0230	119	0.0076	0.0074
198	0.0401	0.0382	158	0.0234	0.0226	118	0.0072	0.0070
197	0.0397	0.0378	157	0.0230	0.0222	117	0.0068	0.0066
196	0.0392	0.0374	156	0.0226	0.0218	116	0.0064	0.0062
195	0.0388	0.0371	155	0.0222	0.0214	115	0.0060	0.0058
194	0.0384	0.0367	154	0.0218	0.0210	114	0.0056	0.0054
193	0.0380	0.0363	153	0.0214	0.0206	113	0.0052	0.0050
192	0.0375	0.0359	152	0.0210	0.0202	112	0.0048	0.0046
191	0.0371	0.0355	151	0.0206	0.0199	111	0.0044	0.0043
190	0.0367	0.0351	150	0.0202	0.0195	110	0.0040	0.0039
189	0.0363	0.0347	149	0.0198	0.0191	109	0.0036	0.0035
188	0.0359	0.0343	148	0.0194	0.0187	108	0.0032	0.0031
187	0.0355	0.0340	147	0.0190	0.0183	107	0.0028	0.0027
186	0.0351	0.0336	146	0.0186	0.0179	106	0.0024	0.0023
185	0.0347	0.0332	145	0.0182	0.0175	105	0.0020	0.0019
184	0.0343	0.0328	144	0.0177	0.0171	104	0.0016	0.0016
183	0.0339	0.0324	143	0.0173	0.0167	103	0.0012	0.0012
182	0.0334	0.0320	142	0.0169	0.0163	102	0.0008	0.0008
181	0.0330	0.0316	141	0.0165	0.0160	101	0.0004	0.0004
						100	0.0000	0.0000

The portion of the table below should not be used unless the sample of oil has been examined and found free from crystals.

Observed Temperature, deg. Fahr.	Correction Factor to be Subtracted from Observed Specific Gravity		Observed Temperature, deg. Fahr.	Correction Factor to be Subtracted from Observed Specific Gravity		Observed Temperature, deg. Fahr.	Correction Factor to be Subtracted from Observed Specific Gravity	
	Group I	Group II		Group I	Group II		Group I	Group II
99	0.0004	0.0004	84	0.0063	0.0062	69	0.0122	0.0121
98	0.0008	0.0008	83	0.0067	0.0066	68	0.0126	0.0125
97	0.0012	0.0012	82	0.0071	0.0070	67	0.0130	0.0129
96	0.0016	0.0016	81	0.0075	0.0074	66	0.0134	0.0133
95	0.0020	0.0020	80	0.0079	0.0078	65	0.0138	0.0136
94	0.0024	0.0023	79	0.0083	0.0082	64	0.0142	0.0140
93	0.0028	0.0027	78	0.0087	0.0086	63	0.0146	0.0144
92	0.0032	0.0031	77	0.0091	0.0090	62	0.0150	0.0148
91	0.0036	0.0035	76	0.0095	0.0094	61	0.0154	0.0152
90	0.0040	0.0039	75	0.0099	0.0098	60	0.0158	0.0156
89	0.0043	0.0043	74	0.0103	0.0101			
88	0.0047	0.0047	73	0.0107	0.0105			
87	0.0051	0.0051	72	0.0111	0.0109			
86	0.0055	0.0055	71	0.0115	0.0113			
85	0.0059	0.0058	70	0.0118	0.0117			

TABLE II.—FACTORS TO BE USED FOR DETERMINING THE VOLUME OF CREOSOTE OIL AT 100° F. WHEN THE OIL IS AT TEMPERATURES RANGING FROM 60 TO 220° F.

Group I.—For Distillate Creosote Including Distillate Water-Gas-Tar Creosote, Having a Specific Gravity at 100°/60° F. (37.8°/15.56° C.) Below 1.0900.

Group II.—For High Boiling Distillate Creosote Oils Having a Specific Gravity at 100°/60° F. (37.8°/15.56° C.) Above 1.0900.

The observed volume is to be multiplied by the factor corresponding to the observed temperature.

Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature		Observed Temperature. deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature		Observed Temperature, deg. Fahr.	Volume at 100° F. Occupied by Unit Volume at Indicated Temperature	
	Group I	Group II		Group I	Group II		Group I	Group II
220	0.9526	0.9570	180	0.9684	0.9711	140	0.9842	0.9855
219	0.9530	0.9573	179	0.9687	0.9714	139	0.9846	0.9858
218	0.9534	0.9577	178	0.9691	0.9718	138	0.9850	0.9862
217	0.9538	0.9580	177	0.9695	0.9721	137	0.9853	0.9866
216	0.9542	0.9584	176	0.9699	0.9725	136	0.9857	0.9869
215	0.9546	0.9587	175	0.9703	0.9729	135	0.9861	0.9873
214	0.9550	0.9591	174	0.9707	0.9732	134	0.9865	0.9876
213	0.9554	0.9594	173	0.9711	0.9736	133	0.9869	0.9880
212	0.9558	0.9598	172	0.9715	0.9739	132	0.9873	0.9884
211	0.9561	0.9601	171	0.9719	0.9743	131	0.9877	0.9887
210	0.9565	0.9605	170	0.9723	0.9746	130	0.9881	0.9891
209	0.9569	0.9608	169	0.9727	0.9750	129	0.9885	0.9894
208	0.9573	0.9612	168	0.9731	0.9754	128	0.9889	0.9898
207	0.9577	0.9615	167	0 9735	0.9757	127	0.9893	0.9902
206	0.9581	0.9619	166	0.9739	0.9761	126	0.9897	0.9905
205	0.9585	0.9622	165	0.9743	0.9764	125	0.9901	0.9909
204	0.9589	0.9626	164	0.9747	0.9768	124	0.9905	0.9913
203	0.9593	0.9629	163	0.9751	0.9772	123	0.9909	0.9916
202	0.9597	0.9633	162	0.9754	0.9775	122	0.9913	0.9920
201	0.9601	0.9636	161	0.9758	0.9779	121	0.9917	0.9923
200	0.9605	0.9640	160	0.9762	0.9782	120	0.9921	0.9927
199	0.9609	0.9644	159	0.9766	0.9786	119	0.9925	0.9931
198	0.9612	0.9647	158	0.9770	0.9790	118	0.9929	0.9934
197	0.9616	0.9650	157	0.9774	0.9793	117	0.9932	0.9938
196	0.9620	0.9654	156	0.9778	0.9797	116	0.9936	0.9942
195	0.9624	0.9658	155	0.9782	0.9800	115	0.9940	0.9945
194	0.9628	0.9661	154	0.9786	0.9804	114	0.9944	0.9949
193	0.9632	0.9665	153	0.9790	0.9808	113	0.9948	0.9952
192	0.9636	0.9668	152	0.9794	0.9811	112	0.9952	0.9956
191	0.9640	0.9672	151	0.9798	0.9815	111	0.9956	0.9960
190	0.9644	0.9675	150	0.9802	0.9819	110	0.9960	0.9963
189	0.9648	0.9679	149	0.9806	0.9822	109	0.9964	0.9967
188	0.9652	0.9682	148	0.9810	0.9826	108	0.9968	0.9971
187	0.9656	0.9686	147	0.9814	0.9830	107	0.9972	0.9974
186	0.9660	0.9689	146	0.9818	0.9833	106	0.9976	0.9978
185	0.9664	0.9693	145	0.9822	0.9837	105	0.9980	0.9982
184	0.9668	0.9696	144	0.9826	0.9840	104	0.9984	0.9985
183	0.9672	0.9700	143	0.9830	0.9844	103	0.9988	0.9989
182	0.9676	0.9704	142	0.9834	0.9848	102	0.9992	0.9992
181	0.9680	0.9707	141	0.9838	0.9851	101	0.9996	0.9996
						100	1.0000	1.0000

The portion of the table below should not be used unless the sample of oil has been examined and found free from crystals.

99	1.0004	1.0004	84	1.0063	1.0057	69	1.0122	1.0111
98	1.0008	1.0007	83	1.0067	1.0061	68	1.0126	1.0115
97	1.0012	1.0011	82	1.0071	1.0065	67	1.0130	1.0118
96	1.0016	1.0014	81	1.0075	1.0068	66	1.0134	1.0122
95	1.0020	1 0018	80	1.0079	1.0072	65	1.0138	1.0126
94	1.0024	1.0022	79	1.0083	1.0075	64	1.0142	1.0129
93	1.0028	1.0025	78	1.0087	1.0079	63	1.0146	1.0133
92	1.0032	1.0029	77	1.0091	1.0083	62	1.0150	1.0136
91	1 0036	1.0032	76	1.0095	1.0086	61	1.0154	1.0140
90	1.0040	1.0036	75	1.0099	1.0090	60	1.0158	1.0144
89	1.0043	1.0040	74	1.0103	1.0093			
88	1.0047	1.0043	73	1.0107	1.0097			
87	1.0051	1.0047	72	1.0111	1.0100			
86	1.0055	1.0050	71	1.0115	1.0104			
85	1.0059	1.0054	70	1.0118	1.0108			

STANDARD METHODS OF TESTING RUBBER PRODUCTS
(A.S.T.M. DESIGNATION: D 15 - 24)[1]

Sections 1 to 47.—A revision in the form of separate tentative methods of chemical analysis entitled "Methods of Chemical Analysis of Rubber Products (D 297 - 31 T)"[2] is intended to replace, when adopted, Sections 1 to 47 of the present standard methods.

Section 48.—Add a new Paragraph (*c*) reading as follows:

(*c*) In case of conflict between the provisions of these methods and those of the detailed specifications for a particular material, the latter shall take precedence.

Section 50.—Change this section from its present form: namely,

50. No tests shall be made within 48 hours after vulcanization unless agreed to by the manufacturer.

to read as follows:

50. No tests shall be made earlier than 24 hours nor later than 60 days after vulcanization except by mutual agreement between the purchaser and manufacturer.

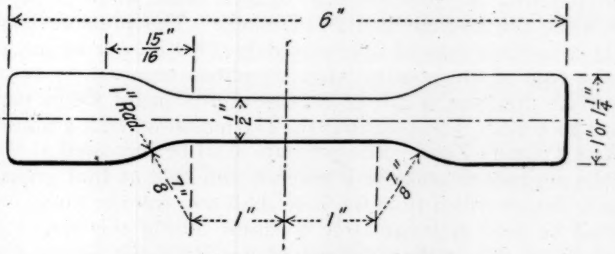

FIG. 1.—½ by 2-in. Specimen.

Section 51. (*b*).—Change to read as follows by the addition of the italicized word and figure and the omission of those in brackets:

(*b*) The samples shall be kept at a temperature within these limits for at least [3 hours] *1 hour* immediately before being tested.

Section 52.—Change the last sentence to read as follows by the addition of the italicized words and figures and the omission of the figures in brackets:

If it is necessary to use gasoline, it shall be of a grade which distills below [239° F. (115° C.)] *302.0° F. (150° C.)* and *which, upon evaporation, does not leave an appreciable amount of oily residue. After use of gasoline,* the specimen shall be allowed to rest at least one hour before being tested.

Figure 1.—Change drawing "(*a*) ½ by 2-in. Specimen" so that the 1¼-in. end dimension is illustrated. The center of the 1 in. radius will then be shown free and not fixed at the edge of the specimen. The revised drawing is illustrated in the accompanying Fig. 1.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Arthur W. Carpenter, Secretary of Committee D-11 on Rubber Products, The B. F. Goodrich Co., Akron, Ohio.

[2] See p. 947.

Section 54 (d).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

(*d*) The thickness shall be measured with a micrometer graduated to 0.001 in. having circular shoes 0.24 to 0.26 in. in diameter and with a pressure on the specimen of [not less than 8 oz. nor more than 10 oz.] *9 oz. ± 0.1 oz.*

Section 59 (a).—Change the second sentence of the second paragraph of this section to read as follows by the addition of the italicized figure and the omission of that in brackets:

The distance through which separation takes place shall be noted for a period of [10] *4* minutes if possible.

Sections 60 to 62.—Change part (*C*) Hydrostatic Tests of Hose from its present form to read as follows:

60. Application and Measurement of Pressure.—The pressure tests for hose shall be made with water by means of a hand or power-driven pump or by means of an accumulator system. The hose shall be connected to the water line or pump and filled with water allowing the air to escape through an air cock. Removal of the air is important for the sake of safety. When the hose is filled with water, the air cock shall be closed and if original measurements of the hose are required, the pressure shall then be raised to 10 lb. per sq. in. and held there while the measurements are taken. The pressure shall then be increased at a uniform rate of approximately 1000 lb. per sq. in. per minute except in the case of fire hose or when otherwise required by detailed specifications. With fire hose, a rate of increase of pressure of 300 lb. per sq. in. per minute shall be used. The pressures shall be measured with a calibrated gage.

61. Time Pressure Tests.—The pressure shall be increased at the specified rate until the designated pressure is reached and held at that pressure for the specified time during which time the hose shall not leak nor burst. The water pressure shall be held approximately constant during this test. In no case shall the pressure exceed that designated nor should it oscillate to a point more than 10 per cent below the specified pressure.

62. Bursting Test.—The pressure shall be increased at the specified rate until failure and the pressure at which failure occurs shall be considered the bursting strength of the hose and shall be not less than that specified. It is permissible to determine the bursting strength on the same sample immediately following the time pressure test if both are required.

63. Retests.—If a sample fails in the hydrostatic pressure test, two additional samples shall be tested and if either of these fails, the entire lot of hose represented by the samples shall be considered to have failed to meet the specifications.

STANDARD DEFINITIONS OF TERMS RELATING TO PAINT SPECIFICATIONS

(A.S.T.M. DESIGNATION: D 16 – 24)[1]

Add the following three new definitions of terms:

Screen (Sieve).—A plate or sheet or a woven cloth, or other device, with regularly spaced apertures of uniform size, mounted in a suitable frame or holder, for use in separating material according to size.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should **be directed to Mr. P. H. Cathcart, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.**

NOTE 1.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties should be taken care of in specifications.

NOTE 2.—In mechanical analysis testing work, when not otherwise specified, the term "sieve" shall apply to an apparatus in which the apertures are rectangular, and the term "screen" shall apply to an apparatus in which the apertures are circular.

***Toughness.*—That quality of a material which may be measured by the maximum impact which it will withstand without rupture.**

***Elasticity.*—In the case of paint or varnish, that property which allows a film to follow, without rupture, changes in the extent and form of the surface to which it is applied.**

STANDARD DEFINITIONS OF TERMS RELATING TO MATERIALS FOR ROADS AND PAVEMENTS

(A.S.T.M. DESIGNATION: D 8 - 18)[1]

Bitumens.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Bitumens.—Mixtures of [native or pyrogenous] hydrocarbons *of natural or pyrogenous origin, or combinations of both* [and] *frequently accompanied by* their non-metallic derivatives, which may be [gases] *gaseous,* [liquids] *liquid,* [viscous liquids] *semisolid,* or [solids] *solid,* and which are *completely* soluble in carbon disulfide.

Asphalts.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Asphalts.—*Black to dark-brown* solid or semi-solid [native bitumens, solid or semi-solid bitumens obtained by refining petroleum, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt upon the application of heat] *cementitious materials which gradually liquefy when heated, in which the predominating constituents are bitumens all of which occur in the solid or semi-solid form in nature or are obtained by refining petroleum, or which are combinations of the bitumens mentioned with each other or with petroleum or derivatives thereof* [and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds].

Flux.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

[Flux] *Fluxes.*—[Bitumens] *Bituminous materials,* generally liquid, *in which the predominating constituent is bitumen,* used in combination with [harder bitumens] *asphalts* for the purpose of softening the latter.

Tars.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Tars.—[*Bitumens*] *Black to dark-brown bituminous condensates* which yield [pitches upon fractional distillation] *substantial quantities of pitch when partially*

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, Asphalt Inst., 801 Second Ave., New York City.

evaporated or fractionally distilled, and which are produced [as distillates] by [the] destructive distillation of [bitumens, pyrobitumens or] organic [materials] *material, such as coal, oil, lignite, peat and wood.*

Pitches.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

Pitches.—*Black or dark-brown* solid *cementitious* residues *which gradually liquefy when heated and which are* produced [in] *by* the *partial* evaporation or *fractional* distillation of [bitumens, the term being usually applied to residues obtained from] tars.

STANDARD DEFINITIONS OF TERMS RELATING TO COAL AND COKE

(A.S.T.M. DESIGNATION: D 121 – 30)[1]

The Tentative Definition of the Term Coke (D 121 – 30 T)[2] is intended to be added, when adopted, to the present standard definitions.

STANDARD DEFINITIONS OF TERMS RELATING TO TEXTILE MATERIALS

(A.S.T.M. DESIGNATION: D 123 – 30)[3]

Several definitions of terms published under the title "Tentative Definitions of Terms Relating to Textile Materials (D 123 – 30 T)"[4] are intended to be added, when adopted, to the present standard definitions.

STANDARD DEFINITIONS OF TERMS RELATING TO METHODS OF TESTING

(A.S.T.M. DESIGNATION: E 6 – 30)[5]

The definitions of the terms "elastic limit" and "yield point" published under the title "Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 30 T)"[6] are intended to be added, when adopted, to the present standard definitions.

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[1] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[2] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1147 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 545.

[3] 1930 Book of A.S.T.M. Standards, Part II. Criticisms of this revision are solicited and should be directed to Mr. W. H. Whitcomb, Secretary of Committee D-13 on Textile Materials, Henry L. Scott Co., Providence, R. I.

[4] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1254 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 865.

[5] 1930 Book of A.S.T.M. Standards, Part I or Part II. Criticisms of this revision are solicited and should be directed to Mr. H. F. Moore, Chairman of the Subcommittee on Mechanical Testing of Committee E-1 on Methods of Testing, University of Illinois, Urbana, Ill.

[6] *Proceedings,* Am. Soc. Testing Mats., Vol. 30, Part I, p. 1263 (1930); also 1931 Book of A.S.T.M. Tentative Standards, p. 898.

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[1] Elected by the Executive Committee, October, 1931, to fill the vacancy caused by the death of Samuel Tobias Wagner, August 7, 1931.

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